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Implications of Rice Cultivar Selection to Optimize Returns from Crop Insurance

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Implications of Rice Cultivar Selection to Optimize Returns from Crop Insurance

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Abstract

Rice production differs from most other field crops by distinct differences in yields across cultivars and rice producers being paid for yield after post-harvest milling. Using eleven years (2003-2013) of Arkansas harvest data from performance trials in six different locations, hybrids have 19% higher paddy yields and head rice yield rate 1.7% lower than conventional cultivars. Given the 2014 Farm Bill's emphasis on crop insurance as a risk management tool for producers, these variations in yield among cultivars have significant implications for rice producers. Comparing national level, crop insurance data on corn, soybeans and rice indicates rice producers strongly prefer yield protection policies (including catastrophic policies) compared with corn and soybean producers who prefer revenue protection. In rice yield and revenue crop insurance policies, no premium distinctions are made on the basis of cultivar. Adjustments for adverse milling outcomes are made only in the most extreme cases. Using an econometric model to predict paddy yields, milled rice yields and head rice yields, the relative returns to yield protection and revenue protection crop insurance are estimated on a per acre basis for both hybrid and conventional cultivars. Additionally, a policy expanding current milling deficiency criteria to milling deficiencies is explored. Results indicate mean loss-cost hybrids exceed mean loss-cost ratios for conventional cultivars for revenue protection by 0.37 and by 0.47 for yield protection. The results also suggest that rice producers should prefer revenue protection policies over yield protection policies (based on economic returns), and they should insure their rice crops at higher buy-up levels than they currently do. A revenue protection policy that would cover adverse milling outcomes would increase the mean indemnity by about 20%.

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Dedication

I would like to dedicate this thesis to a few people who have greatly influenced my life. First, I dedicate this work to my older brother, the late Michael L. Branscum. Michael was an outstanding man who was studying agribusiness at the University of Arkansas before he passed away. He is greatly missed. Next, I dedicate this work to my parents, David & Judy Branscum. I can never thank them enough for everything they have given me in life. I am especially grateful to them for raising me a on a small family farm in Marshall, Arkansas. Next, I dedicate this work to my good friend, Mr. Gerald Fendley Ragland, for encouraging me to pursue a career in agriculture. Lastly, I would like to dedicate this thesis to my wife, Katie Branscum. She is truly an inspiration to me, and I am grateful to her for all of her support and encouragement.

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I. Introduction

The passage of the Agricultural Act of 2014 (2014 Farm Bill) brought numerous changes for farmers across the country. Direct and counter-cyclical payments were eliminated, and the risk management of crop production now focuses more on crop insurance. For crops in states such as Arkansas, which is largely characterized by operators who irrigate their crops, making decisions on crop insurance has taken on added importance because of this increased focus on crop insurance. As Karov et al. argued in 2013, popular crop insurance programs do not target row crop producers who irrigate. High energy costs to lift water increase crop production costs. Crop insurance does not offset increased lifting costs due to drought (Karov et al.). To address the issue of producer's not having adequate crop insurance policy options, margin protection (MP) policies became available to producers in Arkansas in 2016 but participation in all years since then has been negligible (less than 0.01%). Arkansas' second most important revenue crop is rice, and in 2016 Arkansas was responsible for 42% of US rice revenues.[1] Rice received favorable treatment in terms of direct and counter cyclical payments under the previous farm bill program. With the shift to crop insurance, it is important to take a closer look at the current crop insurance program for rice. The current program may fall short of adequately protecting against the risks associated with growing rice such as poor rice milling quality.

Rice producer participation intensity for crop insurance has been low relative to corn and soybeans (USDA, RMA. 2018). On a national basis, the insured proportions of planted acres of corn, soybeans and rice have been roughly the same for corn and soybeans (averages of proportions from 2014 to 2017) of 88% and 89% with a corresponding average for rice of 94%.[2] However, rice producer participation in terms of buy-up crop insurance coverage (coverage greater than the 50% guarantee) has been much lower. At the national level, five-year (2014-2018) proportions of policies by buy-up level, rice had 38% of its policies at the 50% level whereas corn and soybeans only had 7% and 6% of their policies at the 50% buy-up level. At the higher buy-up levels, the proportions of rice policies are much lower than for corn and soybeans. Accordingly, 82% of corn and 84% of soybean policies were at the 70% buy-up level or higher and only 50% of rice policies were beyond this threshold from 2014-2018. The lower level of rice coverage is perplexing because from 2001-2017, rice had the highest gross loss ratio (total indemnities divided by total premiums) among the seven major US crops (Zulauf et al., 2018). Furthermore, rice gross and net loss ratios (indemnity divided by premium less subsidy) for 2014-2017 exceeded one for both ratios in all four years whereas corn and soybeans had four and six ratios less than one over the same period. In 2015 and 2017, rice crop indemnities in Arkansas accounted for 50% and 57%, respectively, of the total indemnities paid to corn, soybeans and rice in Arkansas.

Rice producers are more likely to buy yield protection (YP) and catastrophic (CAT) policies (62% of total policies sold from 2014-2017) compared with corn and soybeans which had much larger proportion revenue protection (RP) and RP policies with harvest price exclusion (RPHEP) (87% for corn and 88% for soybeans).[3] While rice yields are less variable on an annual basis than corn and soybeans, YP provides replanting and preventive planting coverage, which are more important for rice production. Excessive rainfall during the spring planting months is not uncommon in the Mississippi River Delta, and this prevents rice producers from being able to plant their rice crop. The number of CAT policies for all row crops in Arkansas declined from 13,295 policies sold in 2014 to 9,714 policies sold in 2017 (USDA, RMA. 2014 & 2017).

Unlike other row crops, yield and the outcome of post-harvest processing affect rice producers' revenues. Rice prices at the mill are directly affected by the milling quality of the paddy (rough rice) yield delivered. Milling takes two forms with rice. The milled rice yield (MRY) is the proportion of paddy rice that becomes either head rice or broken rice. The head rice yield (HRY) is the proportion of paddy rice resulting in kernels that are at least three-fourths whole (Hardke and Siebenmorgen, 2013). Current crop insurance programs provide minimal protections to offset losses due to poor milling outcomes. The current industry standard for rice milling rate is 70% for MRY and 55% HRY, and any milling rate less than the standard isconsidered poor. A poor milling rate results in discounts to the producer's revenue. The current crop insurance programs offer protection to the producer only when the MRY and/or HRY are below 68% and/or 48% respectively (USDA, RMA. 2018). Hence, there is a gap between how rice revenues are insured and how they are realized by rice producers. Because the weather factors that affect milling yield do not necessarily directly affect paddy yield, there are crop seasons where paddy yields are good, however, milling yields are highly variable. The present investigation explores a potential policy to provide rice producers protection from adverse milling outcomes such as brokens and low head rice yield.

Over the past decade, the US rice industry has increased the proportion of rice acreage planted to hybrids, going from less than 10% in 2004 to over 38% in 2017 (Hardke 2018). In general, hybrids have higher paddy yields than conventional cultivars, but often less favorable milling quality (Lanning and Siebenmorgen, 2011). For the data used for this study, hybrids mean paddy yield was 19% higher than conventional cultivars, but head rice yield rates were 1.8 percentage points lower for hybrid rice. There are several explanations for perceived inferior milling in hybrid rice such as improper milling techniques, excessive chalkiness, etc., but generally hybrids mill lower (Lanning and Siebenmorgen, 2011). According to data from the University of Arkansas, Division of Agriculture, hybrid seed costs for 2018 are estimated at approximately $126.50 per acre compared to approximately $36 per acre for conventional rice seed (Watkins et al., 2018). Watkins et al. project that total operating costs per acre of hybrids exceed those of conventional varieties by $81. The increasing use of hybrids in rice planting poses an interesting situation for both producers and crop insurance providers. The only factors used in writing policies are four to ten years of actual production history (APH), location (by state and county), and buy-up level (50%-85%). Producers may select the insurance policy type and level of coverage. Premium costs do not distinguish between hybrid and conventional cultivars. Studies have yet to examine the benefits of rice crop insurance programs as a function of cultivar. This is important because the cost of hybrid seed exceeds the cost of conventional seed, and hybrid cultivar paddy yields exceed those of conventional cultivars.

Multiple crop insurance programs are available to rice producers such as revenue protection, yield protection, and margin protection. All rice is irrigated in Arkansas and water is generally pumped to minimize moisture scarcity. Consequently, rice producers might be expected to value revenue protection or margin protection since the irrigation itself protects the producers' rice yields from varying. RP provides direct protection due to revenue (price) variation and not solely on yield variation. RP protects farmers according to a revenue guarantee which is determined by coverage level, APH, and a projected price based on a futures contract price for rough rice as well as a harvest price adjustment if harvest price exceeds the projected price. After harvest, a producer can draw an indemnity on the difference between revenue guarantee and their actual revenue as defined by RMA.[4] Margin protection covers increased costs, but it has not been embraced by producers. Mane and Watkins (2016), using data from

Arkansas, find that margin protection is unlikely to generate indemnities at low levels of buy-up. They hypothesize producers might avoid MP because it is a countywide product and might not provide farm level protection when a particular farm's margins drop.

The "actual revenue" as computed for crop insurance purposes generally does not consider milling quality unless there are extreme milling deficiencies, as previously discussed. For most crops, realized revenue is simply yield per acre multiplied by price per bushel which is how insurance programs compute producer revenue per acre. For rice, however, realized revenue is a function of paddy and milling yield and HR and broken rice price. The prices to rice producers use an industry standard milling rate of 55% HRY and 70% MRY. When a producer's rice mills greater than or less than this industry standard, an adjustment is made to the price received by the farmer. This realized price is used to compute a producer's realized revenue. Milling quality is affected by environmental conditions such as stress during flowering, high nighttime temperatures, low solar radiation, low or high harvest moisture content and others (Hardke and Siebenmorgen, 2013; Cooper et al., 2008; Lyman et al., 2013). As noted earlier, milling quality can also vary as a function of genetic differences between cultivars. Rice producers are being protected using revenue estimates that do not equal their realized revenues. Because of this, a gap exists between producers' current indemnities and their actual exposures. In cases of poor milling, this gap could be upwards of 20% as we show in our analysis. Given the changed risk management structure of the 2014 Farm Bill, producers are relying on crop insurance to protect them against their losses and milling yields can be part of those losses.

This study uses rice production data and weather data from six different research locations across Arkansas in order to predict producer revenues over 1000 stochastic simulations per location and rice cultivar. The weather data are weather variables that impact rice production variables such as paddy yield, HRY, and MRY. Two current crop insurance programs (YP and RP) at 55%, 70%, and 85% buy-up levels for Arkansas rice producers are analyzed relative to location and cultivar. Specifically, we ask what effect do location, cultivar and buy-up have on producer revenue under various crop insurance programs? We also investigate if a revenue protection program that more closely insures against adverse milling outcomes would be more suitable in terms of reducing revenue fluctuations. Since 2014, rice producers have outperformed major crop producers, such as corn and soybeans, in terms of loss ratios related to crop insurance[5]. Rice producers also prefer different crop insurance products than corn and soybean producers. We will examine if rice producers' success from 2014-2017 with crop insurance, relative to corn and soybean producers, has been random or if they are pursuing a good strategy in terms of mitigating risk and maximizing revenue. For the sake of achieving more complete coverage, we examine the outcome of a proposed policy that would more closely compensate for milling deficiencies.

II. Data and Methods

Data

Annual Arkansas Rice Performance Trial (ARPT) data were collected from six locations in Arkansas over ten years (2003-2013[6]). These locations are indicated on Figure 1. The variables collected from these trials include paddy yield in bushels per acre dried to 12% (Y_p), milled rice yield percentage of paddy yield (MRY), head rice yield percentage of paddy yield (HRY), percent harvest moisture content (HMC), cultivar, year of production, and location. The plots were harvested at various HMC levels, but all yields recorded were dried to 12% HMC (Frizzel[7]). Weather observations were collected for each location for each year using the aWhere data base.[8] Weather variables collected included vapor pressure difference[9] (VPD) in Torr, solar radiation (SOLAR) in W/m^2, hours during daylight when temperature is greater than thirty-three degrees Celsius (TD33), hours during nighttime when temperature is greater than twenty-two degrees Celsius (TN22) (Lyman et al. 2013), and mean daily temperature in Celsius (AvgT). Weather variables were observed in two succeeding intervals. Window one (w1) is the time frame from rice plant emerged to when 50% heading was recorded. This time period is referred to as the plant's vegetative stage. Window two (w2) defined as the grain filling stage occurs from one day after 50% heading to harvest of the plant. AvgT is averaged over w1 and w2. Both hybrid and conventional cultivars were planted at the six locations. For the purposes of crop insurance where no distinction is made by cultivar, the cultivars were put into two broad categories: conventional cultivars and hybrid cultivars. Across all years and locations, there were 2,058 observations on conventional cultivars and 460 observations on hybrids.

Using the data collected, six ordinary least squares (OLS) regressions were estimated. Similar to Lyman et al. (2013), paddy yield models, HRY models and MRY models were estimated. Lyman et al. (2013) used pooled data to estimate yield models where the models differed by cultivar planted. In this study, two models (one for hybrid cultivars and one for conventional cultivars) were used to estimate paddy yield. Lyman et al. estimated separate MRY and HRY models for each cultivar in their study. In similar manner, we estimate one MRY model for hybrids and another for conventional cultivars allowing parameter estimates to vary by cultivar. Similarly, two HRY models are estimated, one for hybrid cultivars, and one for conventional cultivars. The results from these estimations are in Appendix A.

Paddy Yield Model

Yield was recorded as rough, paddy yield that has been dried to 12% HMC before milling. Yield was measured in bushels (forty-five pounds of rice per bushel). For the two yield regression models (conventional and hybrid), the natural log of yield (Y_P) is specified as a function of location (Stuttgart, Corning, Keiser, Newport, Pine Tree and Rohwer) and seven different climate variables (w1TN22, w2TN22, w1SOLAR, w2SOLAR, w1VPD, w2VPD and AvgT). In the estimated model, Stuttgart is the base location, so its effect is represented in the intercept term.

These models were used to predict paddy yield for a given location and cultivar. Using this model, Y_P is simulated using @Risk via Microsoft Excel twelve times (six locations, two cultivars per location) to predict yields for all possible location and cultivar combinations. Each simulation has 1,000 repetitions.

MRY Model

MRY is the observed mass percentage of whole and broken rice kernels remaining after milling of paddy rice. In the two MRY regression models (one for hybrids and one for conventional), the logit of MRY (log (MRY/(1 – MRY)) was specified to be a function of the six locations, w1TD33, w2TD33, w1TN22, w2TN22 and HMC.[10] These models were used to predict MRY for a given location for hybrid cultivars and conventional cultivars. The same procedure for simulations was used as for the yield model.

HRY Model

HRY is the observed mass percentage of whole kernels remaining after paddy yield was milled. In the two HRY regression models (one for hybrids and one for conventional) the logit of HRY/MRY was specified to be a function of the six locations, w1TD33, w2TD33, w1TN22, w2TN22, HMC, and HMC squared (HMC2). For the simulation, the same procedure for MRY simulations was used for HRY simulations.

Sources of Uncertainty

Our ultimate goal was to simulate the revenues received by producers under various insurance policies. The simulations recognized four sources of uncertainty and were modeled by random draws according to the hypothesized distributions. The first source of uncertainty is due to uncertainty about the regression parameters since these estimates are based on sample data. In each of the 1,000 simulations a vector of regression coefficients was drawn assuming normality and using the covariance matrix of the parameter estimates. The second source of uncertainty is due to weather variability. Random draws of the weather variables based on the estimated moments of the observed weather over the sample period 2003 – 2013 and across the six locations were used as values for the independent variables in the regressions and multiplied times the random draws of the parameter coefficients (the first source of uncertainty noted above.) The third source of uncertainty is the randomness due to the additive error terms of each regression model. For a given location and cultivar, three error terms on the original regressions were drawn according to a multivariate normal distribution with means zero with the estimated three-by-three covariance matrix of the error terms. After the regression coefficient draws were multiplied times their random draws on the independent variables and the random draws on the error terms were added, all three dependent variables were transformed back to their natural units so that head rice yields and brokens yields in pounds could be computed.

The fourth source of uncertainty was harvest price which is required for computing the actual revenues producers received. Harvest price was simulated using a Black-Scholes options approach (Hull). The February 2017 price for computing rice insurance policies by RMA is $0.104/lbs. Using the RMA rice volatility factor of 0.17, the Black-Scholes process generated random draws on the harvest price.[11]

III. Crop Insurance Models

The simulations for paddy yield (Y_p), MRY, HRY, and price were used to generate distributions of producer revenue to facilitate comparisons of current crop insurance programs available for rice producers. The two current crop insurance programs analyzed were Revenue Protection (RP) and Yield Protection (YP). We also propose and simulate an alternative crop insurance program that might better protect producers from losses related to milling quality. This program is referred to as Milling Revenue Protection (MRP).

Actual production histories (APH) were calculated for each cultivar and location by averaging paddy yield for the four most recent years of data. Projected price is the January mean of the November rough rice contract closing prices, and the projected price is published by RMA every February[12]. The projected price for 2017 was $0.104 per pound of rice, and this is the price used with a volatility factor of 0.17. Harvest price for the purposes of crop insurance is typically the September mean of the November rough rice contract closing prices. Harvest price is simulated as described above. Although the actual September mean of November rough rice closing contact prices was $0.128, we simulate the price 1,000 times since the $0.128 is simply one observation and therefore would not generate any generalizable distributions.

Quality adjustment factors (QAF) were applied to each observation based on the RMA guidelines for quality adjustment.[13] For any observation where MRY was less than 68% or HRY was less than 48%, the following $QAF_{48/68}$ was applied to paddy yield:

$$\text{QAF}_{48/68} = (P_{adj}/P_h) \tag{1}$$

$$Y_{adj} = Y_p \times \text{QAF}_{48/68} \tag{2}$$

where $QAF_{48/68}$ is a proportional adjustment; P_{adj} is the realized price a producer receives after milling quality discounts are applied (explained below); P_h is the harvest price computed for producers and Y_{adj} is the adjusted yield which a producer uses for crop insurance purposes.[14]

The revenues producers actually receive (realize) net of indemnities is determined by paddy yield, harvest price (whole kernel price and broken kernel price), and milling quality of the rice. Observed rice prices are based on the industry standard milling quality of 55% HRY and 70% MRY. Prices received by an individual producer vary based on deviations of a harvested crop from this industry standard. A producer's realized revenue (RR) not including indemnities is calculated as:

$$RR = Y_p \times P_{adj} \tag{3}$$

where:

$$P_{adj} = [P_h + (HRY/(1.00 - 0.55))(P_w) + (\frac{BRY}{1.00-0.15})(P_b)] \tag{4}$$

P_h is the harvest price paid to the producer, P_w is the national loan rate for whole kernels published annually by USDA, *BRY* is the percentage of broken kernels remaining after the milling of paddy rice (MRY – HRY); P_b is the national loan rate for broken kernels published annually by USDA. For this analysis P_w equaled $10.01/cwt and P_b equaled $6.96/cwt.[15] Note that in (1) $QAF_{48/68}$ is truncated to one if it exceeds one and only is less than one for adjustment purposes if MRY is less than 68% or HRY is less than 48% or both. But for the purposes of computing a producer's revenues received at a mill price gets adjusted for any deviation from 55/70.[16]

Revenue Protection

To analyze the impacts on rice farmers of the Revenue Protection (RP) crop insurance policy, the yield, MRY and HRY equations were used with the appropriate pricing mechanism to simulate actual producers' revenue under a RP policy. Actual producer revenues, producer revenues with indemnity payments, the probability of an indemnity payment occurring, and the mean indemnity payment over all observations where an indemnity was triggered are computed for every location and cultivar combination. For RP, revenue guarantees (R_g^{rp}) are computed for each observation based on a given APH, coverage level proportion (*C*), P^{rp} which is the larger value of projected price ($0.104/lbs in all simulations) and the simulated harvest price (P_h).

$$R_g^{rp} = APH \times C \times P^{rp} \quad (5)$$

Coverage level (C) can range from 50%-85% (limits set by RMA) depending on producer preference. For RP, a producer's revenue for insurance payment computations (R_a^{rp}) is estimated based on simulated, adjusted paddy yield per acre (Y_{adj}) and harvest price (P_h).

$$R_a^{rp} = Y_{adj} \times P_h$$

Indemnity payments are triggered when actual revenue, (R_a^{rp}) is less than the revenue guarantee (R_g^{rp}). Producers are paid the difference between the two. Simulations were performed for this policy over two scenarios with C ranging from 55% (0.55) to 85% (0.85) at 15% higher coverage levels.

Yield Protection

The yield protection model was simulated in a similar fashion to the RP simulations to analyze producer revenues, mean indemnity payments, the probability of an indemnity payment occurring, and the mean indemnity payment over all observations where an indemnity was triggered for every location and cultivar combination. For YP, revenue per acre guarantees (R_g^{yp}) are estimated for each observation based on a given APH, coverage level (*C*) and projected paddy rice price (P_p).

$$R_g^{yp} = APH \times C \times P_p.$$

Coverage level can range from 50%-85% (0.50-0.85) depending on producer preference but, we simulate only for 55%, 70% and 85% coverage levels. For RP, a producer's projected revenue (R_a^{yp}) for insurance purposes is based on adjusted paddy yield (Y_{adj}) and projected paddy rice price ((P_p):

$$R_a^{yp} = Y_{adj} \times P_p.$$

Indemnity payments are triggered when actual revenue per acre (R_a^{yp}) is less than the revenue per acre guarantee (R_g^{yp}). Producers are paid the difference between the two. This model was run with C ranging from 55% (0.55) to 85% (0.85) at 15% intervals for coverage levels.

Milling Revenue Protection

As noted earlier, there is a gap in revenue insurance for producers whose milling is above 48% HRY and 68% MRY but one or both of these rates is below 55% HRY and 70% MRY. Such a gap suggests exploring an insurance policy that would protect producers from losses due to such milling deficiencies. In this section we propose a policy much like RP, which we call milling revenue protection (MRP), with provisions to provide producers with coverage for milling deficiencies. In designing and simulating such a policy it is our intention to find the fair market value of such a policy (the mean indemnity) and compare the stability of actual producer revenues under such a policy. For MRP, revenue guarantees are equivalent to R_g^{rp} in (5). For MRP, a producer's realized revenue (RR) which is (3) using the price adjustment due to milling yield deviations as in (4)

Indemnity payments are triggered when actual revenue RR is less than the revenue guarantee (R_g^{rp}). Producers are paid on the difference between the two. This model was simulated with C ranging from 55% (0.55) to 85% (0.85) at 15% intervals.

USDA Cost Estimator

To evaluate the RP and YP programs, premium levels were needed for each location and cultivar. The USDA Cost Estimator[17] program was used to estimate the producer paid premium[18] per acre for a given location and cultivar. It should be noted that even though simulations vary between hybrid and conventional, no distinction is made by the Cost Estimator on the basis of cultivar. Therefore, differing by cultivar characteristics might favor one cultivar over the other. For each research station, location was defined as the county in which the station resided. In addition to that, each location and cultivar's APH for the most recent four years[19] of data was used as "Approved Yield" and "Rate Yield". Since there were no substitution yields or yield floors used, Approved Yield always equaled Rate Yield.[20] We also assumed complete ownership of the crop by producers, so "Insured Share Percent" always equaled 100%. The projected prices were left at the 100% published price level at $0.104/lbs. After all the information was inputted, the "Get Estimates" button was selected. "Producer Premium Amount" was selected and the premium values for RP and YP are given at various coverage levels.

IV. Results

Sample Characteristics and Estimation

As indicated in Table 1 for all observations pooled, hybrid cultivars have 19% higher ($p < 0.01$) paddy yields than conventional cultivars across all locations. This is consistent with the previous literature about hybrid yield production versus conventional yield production (Jiang, 2016). Hybrids also have larger yield variability ($p < 0.01$) than conventional cultivars with a hybrid standard deviation of 51.5 bushels compared with 38.2 bushels for conventional cultivars. Hybrid and conventional MRY are statistically equal to the industry standard of 70%. Hybrid

HRY averages 2% lower ($p < 0.01$) compared to conventional cultivars, offsetting the hybrid rough rice yield advantage. While hybrid cultivars exhibit lower HRY, hybrid cultivars also have lower milling variation than conventional cultivars by 0.5% for MRY (3.2% for hybrid versus 3.7% for conventional, $p < 0.01$) and 1.3% for HRY (8.8% for hybrid versus 10.1% for conventional, $p < 0.01$).

The sample data from the six research locations over ten years gives a baseline for the cultivar characteristics in Arkansas (Table 2). Location exhibits an important role in production variability, and the location differences on paddy yield, MRY, and HRY and their dispersions are shown in Table 2. Paddy yields were the lowest in Rohwer which is the southernmost of the six locations. Milling quality was also the worst in Rohwer. Newport and Corning posted the highest paddy yields, and Corning had higher MRY and HRY for both hybrid and conventional cultivars than any other location. In five of the six locations, hybrids had a larger yield standard deviation than conventional cultivars.

As is clear from Tables 3 and 4 that display premiums for RP and YP, Newport clearly has the highest premiums. This could be explained by high yields and large standard deviations, but Keiser has high standard deviations although lower mean yields but premiums roughly 67% those of Newport. This seeming anomaly may be explained by a claims history not evident in our data. This anomaly may also be an artifact that the six locales are at one specific point in each county. The premiums likely reflect actual claims histories from the entire county over many years which may exhibit variability not evident in our site-specific data.

Differences Between Revenue Protection and Yield Protection

Location affects yield and milling quality due to differences such as soil type and climate. This suggests different cultivars may be more suitable to some locations and insurance policy types. Results from simulating production and revenue based on location, cultivar, and climate under RP and YP are displayed in Tables 3 and 4 for coverage at 55%, 70% and 85%. “Loss-Cost Ratio” is the mean indemnity payment over 1,000 iterations divided by producer paid premium. The larger the ratio, the more valuable the crop insurance plan and vice versa. In three locations, Stuttgart, Rohwer and Pine Tree, showed RP and YP policies have higher ratios for hybrid cultivars than conventional cultivars. The opposite happened in Newport and Corning, and in Keiser neither cultivar exhibited substantive differences in loss cost ratios. The average of the 18 (six locations across the three buy-up levels) Loss-Cost ratios for hybrids (2.15 (RP) and 2.10 (YP)) and the 18 for conventionals (1.79 (RP) and 1.63 (YP)) show that the mean for hybrids is greater in tables 3 and 4 are than the respective means for conventionals. Moreover, the mean Lost-Cost ratios for RP exceed those of YP for the respective cultivars.

For RP and YP, hybrid cultivars grown in Stuttgart proved to have highest Loss-Cost ratios at the 55%, 70% and 85% coverage levels across the six locations. This is undoubtedly due to the high Stuttgart APH for hybrids (222 bu/ac) relative to the mean yield (202 bu/ac) when compared with conventionals’ APH (180 bu/ac) compared to mean yield (173 bu/ac). In Newport a reverse situation appears where APH is much lower (34 bu/ac lower) for hybrids than their mean yields and not nearly as large of a spread for conventionals. Newport’s loss cost ratios are much lower than Stuttgart’s for both hybrid and conventional cultivars. In the Corning case the APH for hybrids (228 bu/ac) is lower than the mean hybrid yield (244 bu/ac) but conventionals’ APH (204 bu/ac) is higher than its mean (193 bu/ac). The location least affected by differences between APHs and their respective mean yields is Pine Tree where APH for hybrids equals its mean, 206 bu/ac, and conventionals’ APH differ by 1 bu/ac. At that location, hybrids have higher loss-cost ratios for both RP and YP. Since the mean yield advantage for hybrids is offset by its APH, the difference might be due to the greater variability of hybrid yields.

These results indicate that having an APH higher than the long-term yield trend is advantageous for producers. So, producers with a low APH relative to their long term mean yields are less likely to benefit from YP or RP. In our simulations, the premia are not calibrated sufficiently to offset this disadvantage.

An intriguing pattern emerges in the magnitudes of loss cost ratios going from 55% to 70%. For both policies, all locations and both cultivars, the loss cost ratios increase in going from 55% to 70%. For RP, in eleven of the twelve scenarios, loss cost ratios decline in going from 70% to 85%. A different result occurs for YP. In seven of the twelve scenarios, the loss cost ratio increases between the 70% to 85% buy-up although the loss ratios from 70% to 85% are within 2%-3% of each other, much closer than in the RP case. Revenue protection policies proved to have higher indemnity to premium ratios than YP policies for every location and both cultivars at the 55% and 70% levels except for hybrids in Stuttgart. At the 85% level, nine of the twelve comparisons favored YP. On average, at 55% and 70%, RP loss cost ratios exceeded YP ratios by 0.38 and 0.14. At 85%, the mean YP ratio exceeded the mean RP ratio by 0.22. However, if coverage is at the 85% level, YP is likely preferable. This suggests RP has a better return on premia at the 55% and 70% levels.

In differentiating by cultivar and buy-up level, the mean RP loss cost ratio for conventionals exceeds those for YP by 0.6 and 0.10 at 55% and 70%. In contrast, at 85% the mean hybrid YP loss cost ratio exceeds the mean RP ratio by 0.13. So, there is some interaction between cultivar, policy type and buy-up level.

Revenue protection policies also had higher mean indemnity payments and indemnity frequencies for every cultivar, location and buy-up level. Revenue protection policies also have higher premium costs than YP policies to accommodate for increased protection against price fluctuations. The premiums between hybrid cultivars and conventional cultivars were roughly equal for a given policy type (RP or YP) at a given location. On average, RP premiums were 12% higher for hybrid cultivars compared to conventional cultivars, and YP premiums were 10% higher for hybrid cultivars compared to conventional cultivars. Since crop insurance policies do not factor in cultivar variation in premium costs, hybrid cultivars mean differences in loss cost ratios between hybrid and conventional cultivars averaged over buy-up levels are 0.37 for RP and 0.47 for YP. However, if Stuttgart is removed from these calculations, the mean differences reduce to 0.07 and 0.04. So, it appears hybrids have an edge in return per dollar of premium in both RP and YP policies, likely due to the increase in yield variation for hybrid cultivars over conventional cultivars.

Milling Revenue Protection

Our proposed MRP policy can only be evaluated on indemnity frequency and mean indemnity paid since the premium costs cannot be calculated with the USDA Cost Estimator. The mean indemnities and indemnity frequencies by cultivar and location are displayed in Table 5. As to be expected, the mean indemnities and frequencies of indemnities for MRP exceed those for RP. Across all coverage levels, the MRP mean indemnity for hybrids was 20% higher than for the mean RP indemnity. Likewise, the mean MRP indemnity across all conventional cultivars was 18.7% higher than the mean RP conventional cultivar indemnity. The gap between MRP and YP is greater with mean MRP hybrid indemnities 148% higher than mean YP conventional indemnities. For conventional varieties MRP mean indemnities exceeded those of

YP by 109%. Figures 2 and 3 show that MRP provides producers with increased mean indemnity payments (Figure 2) and increased indemnity frequencies (Figure 3) although the margins between MRP and RP indemnities are narrow, they do expand with the buy-up level. The increased indemnity payments and frequencies come from expanding the quality adjustment threshold. As a consequence, premiums for MRP would likely be higher than for RP, roughly 20% given the increase in the mean indemnities cited above.

Producer Revenue Risk Reduction

In Tables 6-8, mean producer realized revenue is shown with and without mean indemnity payments from RP, YP, and MRP. Comparing realized revenue between hybrid cultivars and conventional cultivars, hybrids have higher revenues than conventional cultivars across all locations as would be expected given hybrid's higher mean yields. Conventional cultivars, however, have lower variation in realized revenue than hybrid cultivars, as shown by the standard deviations in Tables 6-8. The same holds true for realized revenue plus indemnity payments. Hybrid cultivars have higher variability than conventional cultivars in realized revenue. As shown in the tables, coefficients of variation (standard deviation divided by the mean) which are measures of relative risk, are lower in realized revenue for conventional cultivars. For total revenue, the RP has seventeen of eighteen differences (three buy-up levels for each location) in coefficients of variation favor hybrids as riskier. The same is true in YP and MRP. For YP, seventeen of eighteen differences favor conventional cultivars as less risky which is also true for MRP in seventeen of eighteen cases.

When comparing crop insurance policies, Tables 6-8 show that RP and MRP decrease producer revenue variation more compared to YP. Producers selecting RP or MRP can expect to see higher realized revenues (with indemnities) than those who enroll in YP (Figure 4).

Premiums are not deducted out of the mean revenues (because we have no premium for MRP), but in viewing Figure 4, even with premiums deducted, producer profits will likely still be greater under RP and MRP given the generally small differences in RP and YP premiums displayed in Tables 3 and 4. There is minimal realized revenue variation difference between RP and MRP although total revenues under MRP have lower standard deviations for all locations and cultivars. Given that the margins are small between indemnity payments between RP and MRP, the differences in total revenues (with indemnities) are also negligible.

Cultivar Selection

Producers make annual decisions on cultivar selection and crop insurance policy selection. As demonstrated in Tables 1 and 2, hybrids have higher mean yields and variation in annual yields than conventional cultivars. This is reflected in the revenues in Tables 6-8. This variation carries over when indemnities are added to realized revenues. Hybrid cultivars have higher variation among realized revenues (with indemnities) than conventional cultivars for all locations, policy types and buy-up levels. As noted earlier, hybrid seed costs more than conventional seed and has higher overall operating costs so this must be considered adjusting expected net revenues.

As evident from the results in Tables 3 and 4, cultivar selection and the best ratio of indemnity to premium is very much influenced by the difference between APH and mean yields over a longer period of time. The most neutral site for comparing hybrid versus conventional is Pine Tree. For both RP and YP, hybrids have higher loss cost ratios than conventional cultivars. Moreover, the reduction in revenue standard deviations due to insurance is less for conventional cultivars in four of the six locations with Newport and Corning the exceptions.

V. Conclusion

The 2014 Farm Bill made crop insurance the cornerstone for risk management in the rice industry. Our analysis shows that hybrid cultivars generate higher variability in producer realized revenues and higher total realized revenues compared to conventional cultivars. Producers must decide between selecting a less risky cultivar or a cultivar with the potential of higher revenues with greater risk. Our analysis also showed that hybrids had higher mean (averaged over the six locations) Loss-Cost ratios over conventional cultivars for any buy-up level for both RP and YP policy types. Our analysis indicates hybrids offered a better return on premiums than conventional cultivars when APH equaled long run expected yields for both yield protection and revenue protection. While this finding is particular to a given county and requires further research, it suggests that because of different yield and milling characteristics, perhaps premia should be determined separately for hybrids versus conventional cultivars. While cultivar currently is partially incorporated into premia via the APH effect, the greater variability of hybrid yields, and poorer milling properties are not. Our results also indicate the sensitivity of loss cost ratios to the relationship of APH to longer term yield trends. An APH higher than the longer-term trend indicates better returns to policies and the reverse for APH lower than longer term trend.

Arkansas rice producers showed a clear preference for yield protection policies over revenue protection policies in 2018. This is somewhat perplexing because our results show that RP has a better return per dollar of premium at lower buy-up levels (55% and 70%) and YP at 85% buy-up. Since Arkansas rice producers have displayed a clear preference for lower buy-up levels, RP would seem the policy type to be preferred. Our results also show increasing loss cost ratios going from 55% to 70% buy-up, so it would seem rice producers should be purchasing higher buy-up levels.

Revenue protection as currently sold does not provide protection against adverse milling yields except in extreme cases. Our proposed milling revenue protection policy of covering all adverse milling yields at some level indicate that such coverage would further decrease total revenue variability. To pay for this additional protection, higher premiums would likely be charged than current revenue protection premiums which we estimate at a 20% increase.

Our analysis focused on two existing policies—revenue protection and yield protection—and a third that insures producers against more modest milling quality deviations than is the current policy. As Karov et al. concluded in their study on crop insurance in the Southern United States, current crop insurance does not protect producers' profit margins in the South. The rice margin protection policy currently offered by RMA has not been popular. High energy costs due to irrigation are the main source of variation in Arkansas production costs. An insurance policy based solely on irrigation needs throughout the growing season is deserving of further consideration.

VI. Endnotes

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[1] http://www.ers.usda.gov/data-products/state-fact-sheets.aspx Accessed June 27,2018

[2] Authors' computations from RMA and NASS data.

[3] Author's computations using RMA data for YP, CAT, RP and RPHPE policies sold.

[4] For insurance purposes, actual revenue is actual paddy yield times the September mean of the November rough rice closing price. Yield protection follows the same model except price stays constant between revenue guarantee and actual revenue.
http://www.rma.usda.gov/fields/ms_rso/2014/ricearkmstn.pdf

[5] https://prodwebnlb.rma.usda.gov/apps/SummaryofBusiness/

[6] Usable observations were not available for 2011. Data were obtained from:
University of Arkansas Cooperative Extension Service (UACES). Various Years. Arkansas rice performance trials (ARPT). Available at:
http://www.aragriculture.org/crops/rice/PerfTrials/default.htm

[7] Personal communication, Donna Frizzel, June 25, 2014.

[8] http://www.awhere.com/en-us/weather-details

[9] VPD is a measure of humidity.

[10] The logit transformation was used to avoid getting predicted MRY greater than one or less than zero.

[11] The exact formula is: $EXP(ln(0.139)-(0.5*(.10)^2)*(0.75)+(\varepsilon)*(0.10)*(0.75)^{0.5})$ where ε is a randomly generated standard normal random variable.

[12] https://prodwebnlb.rma.usda.gov/apps/PriceDiscovery/GetPrices/YourPrice

[13] https://www.rma.usda.gov/-/media/RMAweb/Handbooks/Coverage-Plans---18000/Crop-Insurance-Handbook---18010/2019-Crop-Insurance-Handbook.ashx

[14] Marvin Dearien, Rain and Hail, LLC. Personal communication, August 27, 2014

[15] https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Price-Support/pdf/2017/2017ricelr.pdf

[16] If P_{adj} in (4) is divided by P_h we get $QAF_{55/70}$.

[17] https://ewebapp.rma.usda.gov/apps/costestimator/

[18] Crop insurance premiums are subsidized by the federal government.

[19] APH for each location and cultivar was estimated as the 4-year average paddy yield for 2009, 2010, 2012, 2013.

[20] Travis Johnson, Risk Management Agency. Personal communication, August 27, 2014.

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VIII. Appendix

Tables

Table 1. Mean paddy yield, MRY, and HRY by cultivar 2003-2013

Cultivar	Variable	n	Mean	Std. Dev.	Minimum	Maximum
Hybrid	**Yield (bu/ac)**	460	210	51.5	35	336
	MRY (%)	460	70	3.2	53	82
	HRY (%)	460	57	8.8	18	72
Conv.	**Yield (bu/ac)**	2058	176	38.2	12	325
	MRY (%)	2058	70	3.7	42	98
	HRY (%)	2058	59	10.1	7	90

Note: Data does not include 2011 because of insufficient observations

Table 2: Mean paddy yield, MRY, HRY and APH by location and cultivar (2003-2013)

Location	Variety	n	APH (bu/ac)	Yield (bu/ac)	MRY (%)	HRY (%)
Stuttgart	Hybrid	**83**	**222**	**202**	**70**	**58**
	Std. Dev.	_		*41.8*	*1.9*	*5.3*
	Conventional	**413**	**180**	**173**	**70**	**63**
	Std. Dev.	_		*27.8*	*2.4*	*5.7*
Keiser	Hybrid	**93**	**196**	**189**	**69**	**56**
	Std. Dev.			*59.7*	*4.0*	*8.3*
	Conventional	**425**	**185**	**172**	**69**	**57**
	Std. Dev.			*42.6*	*4.9*	*10.1*
Rohwer	Hybrid	**34**	**160**	**171**	**67**	**48**
	Std. Dev.			*33.0*	*6.7*	*19.2*
	Conventional	**158**	**150**	**151**	**69**	**52**
	Std. Dev.			*33.3*	*6.1*	*19.0*
Newport	Hybrid	**99**	**186**	**220**	**70**	**59**
	Std. Dev.			*50.7*	*2.2*	*5.7*
	Conventional	**426**	**161**	**177**	**70**	**59**
	Std. Dev.			*44.4*	*2.5*	*7.3*
Corning	Hybrid	**97**	**228**	**244**	**71**	**60**
	Std. Dev.			*40.8*	*1.6*	*7.6*
	Conventional	**395**	**204**	**193**	**71**	**60**
	Std. Dev.			*34.1*	*2.7*	*11.3*
Pine Tree	Hybrid	**54**	**206**	**206**	**70**	**57**
	Std. Dev.			*38.2*	*2.5*	*5.7*
	Conventional	**241**	**171**	**172**	**71**	**60**
	Std. Dev.			*30.1*	*3.0*	*6.3*

Table 3. Revenue protection mean indemnities, frequencies and returns to premiums

		Producer Premium ($) Coverage Level			Mean Indemnity ($) Coverage Level			Indemnity Frequency (%) Coverage Level			Loss-Cost Ratio Coverage Level		
Location	**Cultivar**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Stuttgart	Hybrid	5.00	14.00	40.00	19.96	68.37	156.72	17.7	42.8	64.7	3.99	4.88	3.92
	Conv.	4.00	11.00	34.00	7.91	30.95	83.12	8.6	27.9	51.2	1.98	2.81	2.44
Keiser	Hybrid	8.00	18.00	51.00	12.21	42.75	102.81	12.1	31.7	51.3	1.53	2.38	2.02
	Conv.	7.00	18.00	49.00	11.19	38.71	98.23	12.2	31.7	54.9	1.60	2.15	2.00
Rohwer	Hybrid	5.00	12.00	36.00	10.49	31.00	70.96	12.4	25.6	42.8	2.10	2.58	1.97
	Conv.	5.00	11.00	34.00	6.36	23.12	58.36	8.5	23.0	42.8	1.27	2.10	1.72
Newport	Hybrid	15.00	29.00	73.00	4.92	20.40	55.02	5.8	18.1	33.6	0.33	0.70	0.75
	Conv.	14.00	26.00	66.00	6.29	21.93	54.85	8.1	19.6	37.0	0.45	0.84	0.83
Corning	Hybrid	9.00	21.00	60.00	16.93	55.71	128.08	15.0	32.7	54.4	1.88	2.65	2.13
	Conv.	8.00	20.00	55.00	19.86	63.98	143.69	18.5	42.0	63.2	2.48	3.20	2.61
Pine Tree	Hybrid	8.00	19.00	54.00	9.64	37.21	94.65	10.6	27.0	48.0	1.20	1.96	1.75
	Conv.	7.00	16.00	47.00	5.83	23.27	64.46	7.0	22.9	43.1	0.83	1.45	1.37

Note: Mean indemnities are estimated over 1,000 iterations

Table 4. Yield protection mean indemnities, frequencies and returns to premiums

		Producer Premium ($) Coverage Level			Mean Indemnity ($) Coverage Level			Indemnity Frequency (%) Coverage Level			Loss-Cost Ratio Coverage Level		
Location	**Cultivar**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Stuttgart	Hybrid	3.00	9.00	24.00	12.46	49.83	123.74	13.7	36.3	58.7	4.15	5.54	5.16
	Conv.	3.00	8.00	21.00	4.49	20.28	62.17	6.3	21.4	44.6	1.50	2.53	2.96
Keiser	Hybrid	6.00	14.00	37.00	6.85	29.82	79.07	9.5	25.3	45.7	1.14	2.13	2.14
	Conv.	5.00	13.00	35.00	5.73	26.28	75.40	8.3	24.9	48.7	1.15	2.02	2.15
Rohwer	Hybrid	4.00	9.00	24.00	5.48	20.79	53.50	8.5	20.5	37.8	1.37	2.31	2.23
	Conv.	4.00	8.00	24.00	2.78	14.56	43.26	5.4	18.6	37.2	0.69	1.82	1.80
Newport	Hybrid	13.00	23.00	59.00	1.93	11.22	37.26	2.7	11.8	28.5	0.15	0.49	0.63
	Conv.	12.00	21.00	54.00	2.78	13.41	39.54	5.0	14.5	32.5	0.23	0.64	0.73
Corning	Hybrid	7.00	16.00	43.00	9.39	39.07	99.85	11.0	27.1	47.7	1.34	2.44	2.32
	Conv.	6.00	15.00	40.00	11.92	47.17	114.61	14.0	36.6	57.4	1.99	3.14	2.87
Pine Tree	Hybrid	6.00	14.00	39.00	4.79	24.30	68.95	6.2	20.5	41.8	0.80	1.74	1.77
	Conv.	5.00	12.00	34.00	3.01	14.88	46.12	4.6	17.3	35.2	0.60	1.24	1.36

Note: Mean indemnities are estimated over 1,000 iterations

Table 5. Milling revenue protection mean indemnities, frequencies and returns to premiums

		Mean Indemnity ($) Coverage Level			Indemnity Frequency (%) Coverage Level		
Location	**Cultivar**	**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Stuttgart	Hybrid	26.38	82.04	177.49	22.3	47.3	68.2
	Conv.	10.22	36.52	93.68	10.7	31.2	54.8
Keiser	Hybrid	16.92	54.81	123.34	15.9	37.9	56.5
	Conv.	14.93	47.87	114.18	15.6	36.6	59.6
Rohwer	Hybrid	12.64	36.70	81.46	15.0	29.5	47.4
	Conv.	7.60	27.72	69.30	10.4	27.6	49.6
Newport	Hybrid	6.13	24.98	65.69	7.3	21.8	39.1
	Conv.	8.29	27.91	66.80	11.1	24.5	42.7
Corning	Hybrid	22.46	70.69	153.37	19.7	39.5	59.2
	Conv.	24.01	75.39	163.57	22.4	48.0	68.7
Pine Tree	Hybrid	13.68	46.84	110.13	14.1	31.1	52.3
	Conv.	8.50	30.72	77.28	10.5	27.3	47.3

Note: Mean indemnities are estimated over 1,000 iterations

Table 6. Realized producer revenue by location and cultivar under revenue protection ($/ac)

		Mean Realized Revenue	Mean Indemnity			Mean Total Revenue		
			Coverage Level			Coverage Level		
Location	Cultivar		55%	70%	85%	55%	70%	85%
Stuttgart	Hybrid	927.28	19.96	68.37	156.72	947	996	1084
	Std. Dev.	*322*	*56*	*109*	*167*	*300*	*264*	*220*
	CV	0.35	2.79	1.60	1.07	0.32	0.27	0.20
	Conv.	842.53	7.91	30.95	83.12	850	873	926
	Std. Dev.	*264*	*33*	*68*	*114*	*253*	*232*	*197*
	CV	0.31	4.17	2.21	1.37	0.30	0.27	0.21
Keiser	Hybrid	910.88	12.21	42.75	102.81	923	954	1014
	Std. Dev.	*306*	*42*	*84*	*136*	*291*	*264*	*225*
	CV	0.34	3.40	1.97	1.32	0.32	0.28	0.22
	Conv.	852.01	11.19	38.71	98.23	863	891	950
	Std. Dev.	*265*	*37*	*78*	*125*	*251*	*228*	*193*
	CV	0.31	3.34	2.01	1.27	0.29	0.26	0.20
Rohwer	Hybrid	849.79	10.49	31.00	70.96	860	881	921
	Std. Dev.	*302*	*36*	*70*	*110*	*288*	*269*	*240*
	CV	0.36	3.41	2.24	1.55	0.34	0.31	0.26
	Conv.	780.73	6.36	23.12	58.36	787	804	839
	Std. Dev.	*249*	*26*	*55*	*93*	*241*	*225*	*199*
	CV	0.32	4.07	2.39	1.59	0.31	0.28	0.24
Newport	Hybrid	1057.25	4.92	20.40	55.02	1062	1078	1112
	Std. Dev.	*361*	*26*	*57*	*101*	*354*	*339*	*312*
	CV	0.34	5.20	2.79	1.84	0.33	0.31	0.28
	Conv.	855.34	6.29	21.93	54.85	862	877	910
	Std. Dev.	*276*	*27*	*57*	*96*	*268*	*252*	*227*
	CV	0.32	4.29	2.60	1.74	0.31	0.29	0.25

Table 6. Cont.

Location	Cultivar	Mean Realized Revenue	Mean Indemnity Coverage Level			Mean Total Revenue Coverage Level		
			55%	**70%**	**85%**	**55%**	**70%**	**85%**
Corning	Hybrid	1071.27	16.93	55.71	128.08	1088	1127	1199
	Std. Dev.	*371*	*52*	*104*	*164*	*352*	*320*	*277*
	CV	0.35	3.07	1.87	1.28	0.32	0.28	0.23
	Conv.	876.46	19.86	63.98	141.69	896	940	1020
	Std. Dev.	*282*	*54*	*103*	*155*	*260*	*226*	*185*
	CV	0.32	2.72	1.61	1.09	0.29	0.24	0.18
Pine Tree	Hybrid	980.86	9.64	37.21	94.65	990	1018	1076
	Std. Dev.	*330*	*37*	*80*	*134*	*318*	*293*	*256*
	CV	0.34	3.84	2.15	1.42	0.32	0.29	0.24
	Conv.	851.73	5.83	23.27	64.46	858	875	916
	Std. Dev.	*269*	*28*	*59*	*101*	*261*	*243*	*213*
	CV	0.32	4.80	2.54	1.57	0.30	0.28	0.23

Note: Mean indemnities are estimated over 1,000 iterations

Table 7. Realized producer revenue by location and cultivar under yield protection ($/ac)

		Mean Realized Revenue	Mean Indemnity			Mean Total Revenue		
			Coverage Level			Coverage Level		
Location	**Cultivar**		**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Stuttgart	Hybrid	927.28	12.46	49.83	123.74	940	977	1051
	Std. Dev.	*322*	*39*	*89*	*146*	*307*	*278*	*239*
	CV	0.35	3.15	1.79	1.18	0.33	0.28	0.23
	Conv.	842.53	4.49	20.28	62.17	847	863	905
	Std. Dev.	*264*	*22*	*53*	*96*	*258*	*242*	*213*
	CV	0.31	4.87	2.62	1.54	0.30	0.28	0.24
Keiser	Hybrid	910.88	6.85	29.82	79.07	918	941	990
	Std. Dev.	*306*	*28*	*67*	*116*	*297*	*275*	*242*
	CV	0.34	4.07	2.25	1.47	0.32	0.29	0.24
	Conv.	852.01	5.73	26.28	75.40	858	878	927
	Std. Dev.	*265*	*25*	*60*	*106*	*257*	*238*	*207*
	CV	0.31	4.29	2.30	1.41	0.30	0.27	0.22
Rohwer	Hybrid	849.79	5.48	20.79	53.50	855	871	903
	Std. Dev.	*302*	*23*	*53*	*92*	*294*	*278*	*252*
	CV	0.36	4.24	2.57	1.71	0.34	0.32	0.28
	Conv.	780.73	2.78	14.56	43.26	784	795	824
	Std. Dev.	*249*	*15*	*40*	*75*	*245*	*232*	*209*
	CV	0.32	5.34	2.74	1.74	0.31	0.29	0.25
Newport	Hybrid	1057.25	1.93	11.22	37.26	1059	1068	1095
	Std. Dev.	*361*	*14*	*39*	*79*	*358*	*347*	*325*
	CV	0.34	7.25	3.48	2.12	0.34	0.32	0.30
	Conv.	855.34	2.78	13.41	39.54	858	869	895
	Std. Dev.	*276*	*15*	*41*	*77*	*272*	*260*	*238*
	CV	0.32	5.40	3.06	1.95	0.32	0.30	0.27

Table 7. Cont.

		Mean Realized Revenue	Mean Indemnity Coverage Level			Mean Total Revenue Coverage Level		
Location	**Cultivar**		**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Corning	Hybrid	1071.27	9.39	39.07	99.85	1081	1110	1171
	Std. Dev.	*371*	*34*	*82*	*140*	*359*	*332*	*294*
	CV	0.35	3.62	2.10	1.40	0.33	0.30	0.25
	Conv.	876.46	11.92	47.17	114.61	888	924	991
	Std. Dev.	*282*	*39*	*84*	*136*	*267*	*238*	*202*
	CV	0.32	3.27	1.78	1.19	0.30	0.26	0.20
Pine Tree	Hybrid	980.86	4.79	24.30	68.95	986	1005	1050
	Std. Dev.	*330*	*24*	*61*	*111*	*323*	*304*	*273*
	CV	0.34	5.01	2.51	1.61	0.33	0.30	0.26
	Conv.	851.73	3.01	14.88	46.12	855	867	898
	Std. Dev.	*269*	*17*	*44*	*83*	*264*	*252*	*227*
	CV	0.32	5.65	2.96	1.80	0.31	0.29	0.25

Note: Mean indemnities are estimated over 1,000 iterations

Table 8. Realized producer revenue by location and cultivar under milling revenue protection ($/ac)

		Mean Realized Revenue	Mean Indemnity Coverage Level			Mean Total Revenue Coverage Level		
Location	**Cultivar**		**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Stuttgart	Hybrid	927.28	26.38	82.04	177.49	954	1009	1105
	Std. Dev.	*322*	*64*	*120*	*176*	*294*	*256*	*212*
	CV	0.35	2.41	1.46	0.99	0.31	0.25	0.19
	Conv.	842.53	10.22	36.52	93.68	853	879	936
	Std. Dev.	*264*	*37*	*75*	*121*	*251*	*227*	*192*
	CV	0.31	3.61	2.04	1.29	0.29	0.26	0.20
Keiser	Hybrid	910.88	16.92	54.81	123.34	928	966	1034
	Std. Dev.	*306*	*49*	*95*	*147*	*286*	*254*	*213*
	CV	0.34	2.90	1.73	1.19	0.31	0.26	0.21
	Conv.	852.01	14.93	47.87	114.18	867	900	966
	Std. Dev.	*265*	*44*	*87*	*134*	*247*	*221*	*184*
	CV	0.31	2.96	1.82	1.17	0.28	0.25	0.19
Rohwer	Hybrid	849.79	12.64	36.70	81.46	862	886	931
	Std. Dev.	*302*	*39*	*75*	*116*	*286*	*263*	*232*
	CV	0.36	3.09	2.04	1.43	0.33	0.30	0.25
	Conv.	780.73	7.60	27.72	69.30	788	808	850
	Std. Dev.	*249*	*28*	*59*	*98*	*239*	*220*	*191*
	CV	0.32	3.73	2.15	1.41	0.30	0.27	0.22
Newport	Hybrid	1057.25	6.13	24.98	65.69	1063	1082	1123
	Std. Dev.	*361*	*28*	*62*	*108*	*353*	*334*	*303*
	CV	0.34	4.57	2.48	1.64	0.33	0.31	0.27
	Conv.	855.34	8.29	27.91	66.80	864	883	922
	Std. Dev.	*276*	*30*	*63*	*104*	*266*	*247*	*218*
	CV	0.32	3.62	2.26	1.56	0.31	0.28	0.24

Table 8. Cont.

		Mean Realized Revenue	Mean Indemnity Coverage Level			Mean Total Revenue Coverage Level		
Location	**Cultivar**		**55%**	**70%**	**85%**	**55%**	**70%**	**85%**
Corning	Hybrid	1071.27	22.46	70.69	153.37	1094	1142	1225
	Std. Dev.	*371*	*58*	*115*	*175*	*346*	*308*	*261*
	CV	0.35	2.58	1.63	1.14	0.32	0.27	0.21
	Conv.	876.46	24.04	75.39	163.57	900	952	1040
	Std. Dev.	*282*	*59*	*109*	*159*	*256*	*218*	*173*
	CV	0.32	2.45	1.45	0.97	0.28	0.23	0.17
Pine Tree	Hybrid	980.86	13.68	46.84	110.13	995	1028	1091
	Std. Dev.	*330*	*44*	*91*	*145*	*314*	*285*	*246*
	CV	0.34	3.22	1.94	1.32	0.32	0.28	0.23
	Conv.	851.73	8.50	30.72	77.28	860	882	929
	Std. Dev.	*269*	*33*	*68*	*111*	*258*	*237*	*204*
	CV	0.32	3.88	2.21	1.44	0.30	0.27	0.22

Note: Mean indemnities are estimated over 1,000 iterations

Table 9. Regression estimates of paddy yield for hybrid and conventional rice cultivars

Variable	(1)	(2)
Intercept	3.4766***	2.9080***
w1TDN	-0.0003***	-0.0002
w2TDN	0.0001*	0.0005***
w1VPD	0.2771***	0.2522
w2VPD	-0.5649***	-1.3816***
w1SOLAR	-0.0001**	-0.0002**
w2SOLAR	0.0001***	0.0003***
w1w2AvgT	0.0791***	0.1167***
Corning	0.0826***	0.1799***
Keiser	0.0447**	0.0036
Newport	0.0542***	0.1645***
PineTree	0.0190	0.0672
Rohwer	-0.0261	-0.0346
Regression Statistics		
Sample Size	2058	460
R-Square	0.1131	0.2919
F Value	21.74	15.35

Ordinary Least Squares (OLS) regression results for conventional cultivar model (1) and hybrid cultivar model (2). Values in columns (1) and (2) are the coefficient estimates of the independent variables in column "Variable". For this model, Stuttgart is the base location. Also, *, **, *** represent statistical significance at the 0.10, 0.05, and 0.01 levels, respectively. Standard errors are heteroscedasticity robust.

Table 10. Regression estimates of MRY for hybrid and conventional rice cultivars

Variable	(1)	(2)
Intercept	1.6042***	1.6249***
w1TD33	0.0004***	0.0006***
w2TD33	0.0000	0.0000
w1TN22	-0.0009***	-0.0012***
w2TN22	-0.0007***	-0.0007***
HMC	-0.0021***	0.0005
Corning	-0.1352***	-0.1387***
Keiser	-0.1159***	-0.0609***
Newport	-0.1283***	-0.1200***
PineTree	0.0004	-0.0033
Rohwer	-0.1306***	-0.1457***
Regression Statistics		
Sample Size	2058	460
R-Square	0.2528	0.3467
F Value	69.26	23.83

Ordinary Least Squares (OLS) regression results for conventional cultivar model (1) and hybrid cultivar model (2). Values in columns (1) and (2) are the coefficient estimates of the independent variables in column “Variable”. For this model, Stuttgart is the base location. Also, *, **, *** represent statistical significance at the 0.10, 0.05, and 0.01 levels, respectively. Standard errors are heteroscedasticity robust.

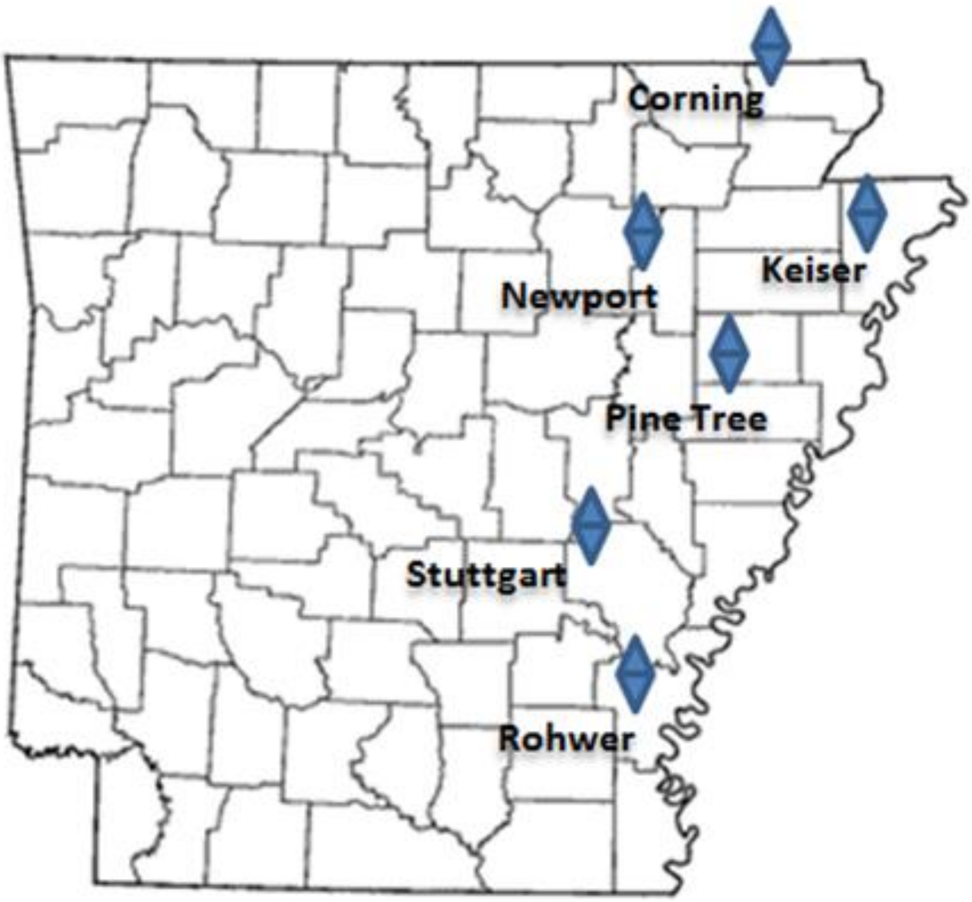
Table 11. Regression estimates of HRY for hybrid and conventional rice cultivars

Variable	(1)	(2)
Intercept	4.1242***	3.6030***
w1TD33	0.0014***	0.0002
w2TD33	-0.0012**	0.0000
w1TN22	-0.0039***	-0.0023***
w2TN22	-0.0028***	-0.0031***
HMC	0.0913***	0.0339
HMC2	-0.0015***	-0.0005
Corning	-0.8783***	-0.3493***
Keiser	-0.4662***	-0.3427***
Newport	-0.7504***	-0.3352***
PineTree	-0.4140***	-0.2439**
Rohwer	-1.0445***	-0.9195***
Regression Statistics		
Sample Size	2058	460
R-Square	0.2731	0.3235
F Value	69.88	19.48

Ordinary Least Squares (OLS) regression results for conventional cultivar model (1) and hybrid cultivar model (2). Values in columns (1) and (2) are the coefficient estimates of the independent variables in column "Variable". For this model, Stuttgart is the base location. Also, *, **, *** represent statistical significance at the 0.10, 0.05, and 0.01 levels, respectively. Standard errors are heteroscedasticity robust.

Figures

Figure 1. Research locations in Arkansas



Source: http://printerprojects.com/maps/arkansasblank.html

Figure 2. Mean Indemnity Per Acre by RP, YP, and MRP at 70% Coverage Level

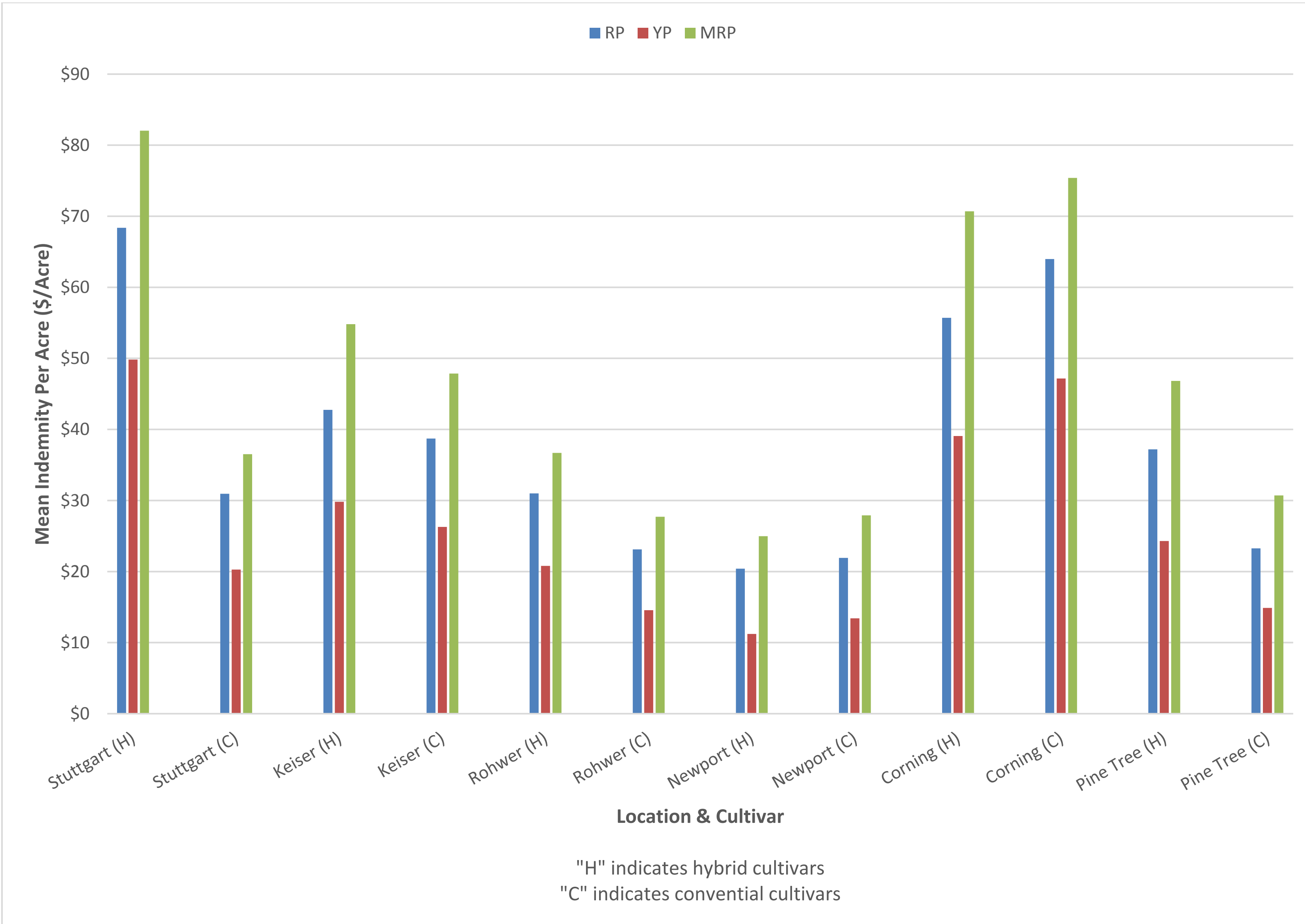


Figure 3. Indemnity Payment Frequency for RP, YP, and MRP at 70% Coverage Level

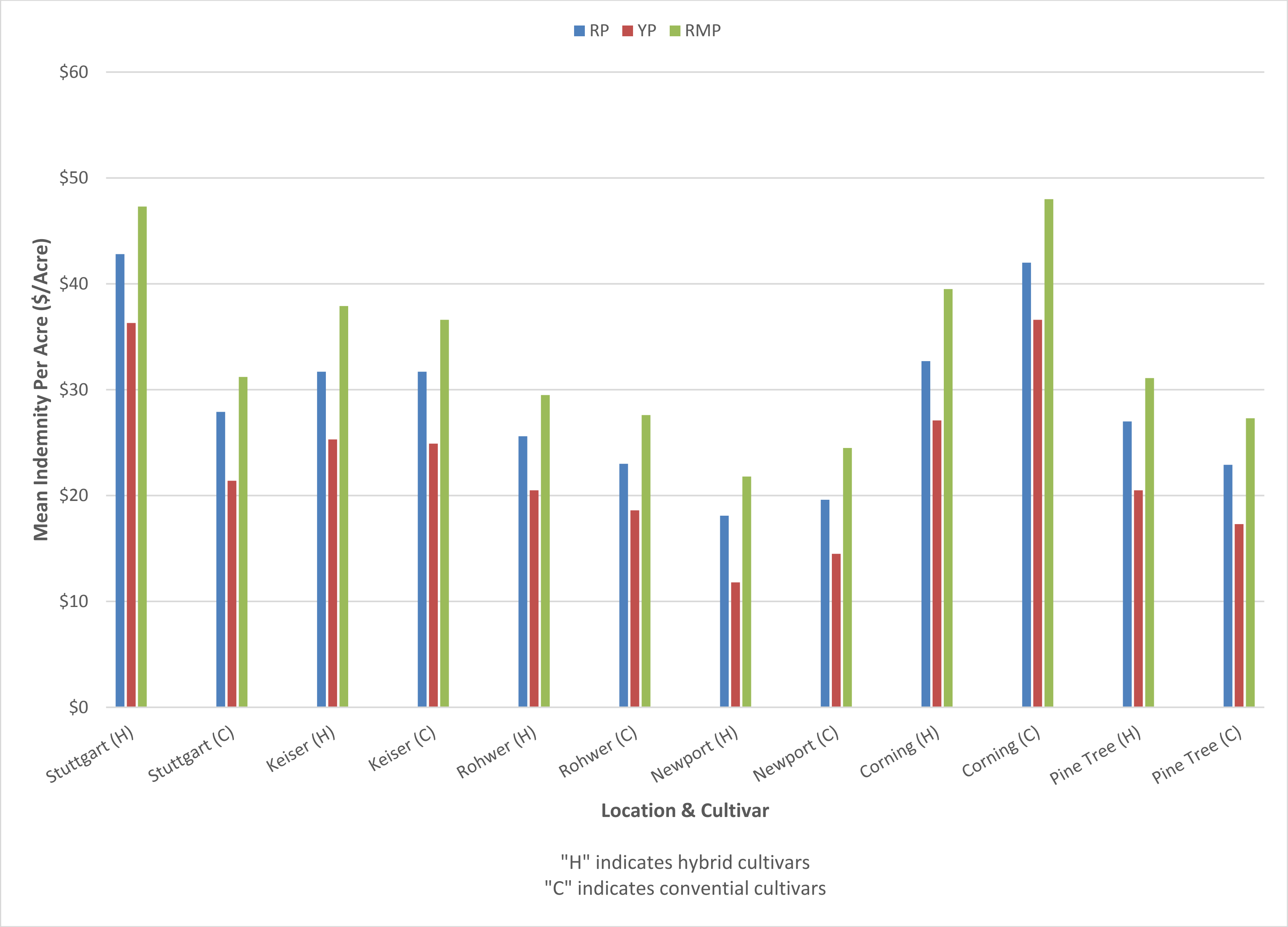


Figure 4. Mean Producer Realized Revenue Plus Mean Indemnity Payments for RP, YP, and MRP at 70% Coverage Level