Loss Adjustment Policy & Procedure Support for the Rice Blanket Purchase Agreement

Final Research Report: Tillering Factors for Hybrid Rice

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I. EXECUTIVE SUMMARY

This report was produced under a contract for the United States Department of Agriculture (USDA) Risk Management Agency (RMA). It provides an evaluation of the "tiller factor" used in crop insurance loss adjustment for early season losses for a rice crop insured under the Federal Crop Insurance Corporation (FCIC) Rice Crop Provisions (11-0018). The Contractor gathered information for the report from a variety of sources including published RMA documents, published and unpublished RMA data, discussions with rice crop experts, and publications from authoritative academic sources relevant to the economic and agricultural characteristics of the rice industry. The telephonic and digital discussions with experts involved primarily individuals whose work focuses on rice breeding and commercial production of rice.

Coverage under the Rice Crop Provisions offers insurance under plan codes 01, 02, and 03 (yield protection, revenue protection, and revenue protection with harvest price exclusion, respectively).[1] The insured liability under those provisions for the 2015 crop year was just over $1.4 billion, while the area insured under those policies was over 2.6 million acres.[2]

Tillers are branches that form from the primary stem of the plant. The current appraisal process for rice losses that occur when tillering is incomplete uses the tiller factor to estimate the number of "live plants" that will exist per acre after tillering is complete. The current tiller factor for rice crop insurance loss adjustment was developed prior to 1998. Information documenting the process used to develop the factor at that time is no longer available. According to the solicitation for the first Task Order, "The crop insurance industry pointed out to RMA that the tillering factor currently used while performing rice appraisals is based on conventional rice varieties only."[3] If it can be documented that tillering of different rice varieties following a loss event are very different, the use of a single tiller factor in appraisals for early season losses is called into question.

For loss adjustment, the estimate of live plants that will exist per acre after tillering is complete is based on the average number of surviving plants at the time of the appraisal in samples taken from the affected field. The estimated number of live plants after tillering is used in the appraisal to calculate an estimate of the pounds of rice that could be produced if the crop were maintained. Since details of actual appraisals using these procedures are documented primarily in the insured's policy file, the exact portion of the insurance affected by use of the tiller factor for rice cannot be established. However, based on the dates of the first cause of loss documented in RMA unpublished data, only a small fraction of the insurance could have been affected by appraisals before tillering was completed.[4]

The process of tillering in rice is by no means consistent, especially when the population of live plants in a field is reduced. This inconsistency is influenced by a wide range of circumstances. Different varieties of rice have different tillering potential, although this potential is rarely realized and the number of tillers per plant within a variety is highly variable. Planting density

[1] Other rice crop insurance is available under area yield and area revenue policies and the Whole Farm Revenue Protection plan.
[2] USDA, RMA, 2016, RMA Summary of Business Report Generator, http://prodwebnlb.rma.usda.gov/apps/SummaryofBusiness/ReportGenerator, accessed April 2016.
[3] USDA, RMA, 2016. Solicitation for Rice Loss BPA (Loss Adjustment Policy & Procedure Support for the Rice BPA, Statement of Work: Tillering Factors for Hybrid Rice, page 2 of 5.
[4] USDA, RMA, 2016, unpublished Type P21 and P11 data for the 2014 crop year.

and planting procedures affect the number of tillers that actually develop in a field. The soil type affects the number of tillers that develop per plant. The timing of a loss event impacts the number of tillers that can be produced; the number of tillers is also influenced by the health of the surviving plant. Furthermore, not all tillers produce panicles. These panicles are clusters of flowers. While most of the flowers will eventually form grains of rice, the percentage that do so can in turn be affected by numerous circumstances. Generally secondary tillers are more likely to form when the plant population is smaller, but are less productive than primary tillers.

For all these reasons, the Contractor found no basis to establish a tiller factor or any set of tiller factors appropriate for adjusting early season losses insured under the FCIC Rice Crop Provisions. Furthermore, consistent with this observation, the Contractor concludes that there is no evidence a set of unique rice tiller factors for different varieties and/or types would have an appropriate predictive value for the yields that would be obtained under loss scenarios affecting these different varieties and/or types.

Based on the wide range of factors that affect tillering, an extremely (and likely exceedingly) large number of permutations and combinations of conditions would need to be evaluated in any field trials to establish additional tiller factors for particular scenarios. There is no evidence these costly and time-consuming efforts would produce appropriate tiller factor values for adjusting early season losses insured under the FCIC Rice Crop Provisions.

Inasmuch as the Contractor could identify no biological or agronomic basis for establishing a different tiller factor, for all rice, for rice by types (including inbred and hybrid rice varieties), or for regions, the Contractor recommends an alternative to the tiller factor procedures be developed for appraisal of early season losses in rice, including for appraisals focused on replant payments. One such alternative would be to require the insured to maintain the crop until an appraisal can be completed following tillering or perhaps even following heading. This approach would address the impact of plant density on yield, the potentially variations in tillering among different rice varieties, the impact of management practices on tillering, and the fact the timing of a loss event will impact the number of tillers that can be produced. However, it could create substantial problems with authorizing replant in a timely manner. Another alternative would be to develop a direct surviving-plant (stand density) to yield factor that eliminates the intervening calculations used in the current early-season-loss appraisal procedures.

Either of these approaches would require substantial additional efforts for implementation. The first approach would likely impose substantial burdens on RMA, AIPs, and insureds while the second approach may be fraught with some of the same challenges inherent in the current early-season-loss appraisal procedures. There may be other alternatives that better address loss adjustment for early season losses insured under the FCIC Rice Crop Provisions. A specific recommendation regarding the most appropriate alternative to the existing approach would require substantial added research beyond the scope of this Task Order.

The Contractor emphasizes that the findings reported in this document are specific to rice. Although the tiller factor method is a part of the loss adjustment process for early season losses in other cereal grains, the Contractor makes no findings with respect to the method for those crops.

II. BACKGROUND

This section of the report provides background information to assist readers in their assessment of the Contractor's recommendations. This contextual information includes an overview of the Blanket Purchase Agreement (BPA) and Task Order (TO) under which the study was conducted; details concerning the specific task order directing the research leading to the Contractor's recommendations regarding tiller factors for hybrid rice; an introduction to rice biology and agronomics; an overview of the role of crop insurance for rice in the United States; and a general summary of crop insurance loss adjustment procedures. The report then continues with sections discussing rice yield components, tillering in rice (with a focus on tillering in commercial varieties), risks affecting rice production in the United States, specific rice crop insurance loss adjustment procedures and experience affected by the tiller factor, and the Contractor's recommendations regarding "the appropriate tillering factor(s) for conventional and hybrid rice varieties, which are used while performing rice appraisals."[5]

The Contract

The United States Department of Agriculture (USDA) Risk Management Agency (RMA) issued a solicitation (D16PS00016) for proposals addressing research on crop insurance loss adjustment procedures for rice. Contracting for this research effort is managed by the Department of Interior (DOI) Acquisition Services Directorate. The Acquisition Services Directorate issued a Blanket Purchase Order (BPA) to the Contractor under Contract Number D16PA00006 providing for research responsive to the solicitation. The Statement of Work (SOW) for the BPA solicitation outlines the potential work under the contract as follows:

> ***2.2 Objective:***
> *The objective of this contract is to establish a Blanket Purchase Agreement* relevant *(BPA) in support of loss adjustment procedures utilized for Rice. This effort will involve several phases that will be accomplished via orders issued under the BPA. The potential tasks are outlined in paragraph 2.4.*
>
> ***2.3 Scope:***
> *This Statement of Work (SOW) provides the framework for the research, analysis, and support necessary for the RMA-issued loss adjustment procedures.*
>
> ***2.4 Specific Tasks and Work Requirements:***
> *Task orders may be issued to obtain the following services/deliverables in regard to the Rice Loss Adjustment Standards Handbook.*
>
> *RMA considers the following components necessary.*
>
> ***2.4.1 Research for Loss Adjustment Procedures:***
> *The government may task the contractor with conducting data gathering of the current risks and issues that the producers face with the loss of their specific crop(s).*

[5] USDA, RMA, 2016. Solicitation for Rice Loss BPA (Loss Adjustment Policy & Procedure Support for the Rice BPA), Statement of Work: Tillering Factors for Hybrid Rice, page 2 of 5.

2.4.2 Appraisal Methodologies:
The government may task the contractor with researching and developing crop specific appraisal methodologies for potential production. This may involve development of appraisal tillering factors, determining and recommending appropriate test weight pack factors, etc. The contractor may develop new, and update current, appraisal methodologies after conducting necessary research on the most appropriate methodology for rice.

2.4.4 Rice Tillering Factors:[6]
The government may task the contractor with researching, updating and establishing tillering factors for appraisals of hybrid rice varieties versus conventional rice varieties.

2.4.5 Serve as a Resource to Address Industry or Expert Review Comments Regarding Loss Adjustment Policies and Procedures:
The Government may task the Contractor to aid RMA in responses to any industry comments or expert reviewers…[7]

The focus of the BPA is on elements of procedures used in adjusting for crop insurance losses, especially where the production is not anticipated to be maintained and where replanting may be required. The SOW for the solicitation for the first TO under the BPA Contract, which served as the basis for the Contractor's proposal focused on this report, calls for a study of the tiller factor, which is used in the adjustment procedures for crop losses that occur early in the growing season. Additional consulting activities related to loss adjustment for rice crop insurance may be required under optional task orders. Language from the SOW for the solicitation regarding the first TO states:

2.1 Objective:
The objective of this [Task Order] *is to conduct research and determine the appropriate tillering factor(s) for conventional and hybrid rice varieties, which are used while performing rice appraisals…*

2.4 Specific Tasks:

2.4.1 Draft Research Report and Teleconference:
The contractor shall review and analyze the Rice LASH to demonstrate understanding of the appraisal methods including the following specific procedures that apply a tillering factor during the appraisal process.

The contractor shall accomplish the following tasks:

- *Gather information from crop insurance industry representatives, rice and hybrid rice producers, researchers, rice grower associations, seed manufacturers, rice research publications, and any other sources that will enable fulfillment of this contract through telephone, email, etc. These*

[6] The break in numbering (i.e., the absence of a point 2.4.3) displayed here is faithfully reproduced from the contract materials.
[7] USDA, RMA, 2016. Solicitation for Rice Loss BPA and Order 1 (D16PS00016), Loss Adjustment Policy & Procedure Support for the Rice BPA, pages 7-8 of 12.

sources shall offer reliable knowledge and information regarding rice production as it relates to the Rice LASH.

- *Determine if the tillering factor utilized for conventional rice and hybrid rice should be different.*
- *Provide the states in which rice, and hybrid rice, is grown.*
- *Determine if it would be best to establish tillering factors on a national basis, as currently done, or if it should be done on a different basis (such as regional basis).*
- *Determine if additional tillering factors should be established by region or state that are more appropriately based on the different rice characteristics such as varieties, yields, practices. etc. When adjusting a loss insured under the federal crop insurance program administered by the United States Department of Agriculture (USDA) Risk Management Agency (RMA), it is desirable to maintain the crop until production to count can be based on actual grain harvested. However, because of the extent of damage causing the loss, make the cost of circumstances* [of] *maintaining the crop unwarranted. Under these circumstances, the additional potential production inherent in the remaining plants must be estimated by an appraisal.*[8]

In response to the requirements of this SOW, the Contractor conducted an extensive examination of the literature regarding conventional and hybrid rice varieties with a special focus on tillering and the tiller factor. A report of the research findings follows.

Rice

Rice is the common name for the wide range of species of perennials in the genus *Oryza*. The genus is in the grass family (Poaceae, formerly called Gramineae) and includes two important agricultural species: *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Both species grow in tropical and warm temperate environments.

Rice is a significant source of food in many cultures, especially in Africa and Asia. While cultivated rice plants can grow two to eight feet in height, commercial varieties in the United States tend to be three to four feet tall.[9] Cultivated rice plants grown in the United States generally mature in less than 150 days, with some commercial varieties maturing in about two thirds that time (depending on variety, location, cultural practices, and weather).[10] An additional period, whose length is influenced primarily by weather, may be required for dry-down.

O. glaberrima was historically a substantial food source in sub-Saharan Africa. African rice was cultivated in the United States during colonial times. *O. sativa* is widely grown outside Africa and is now replacing *O. glaberrima* in much of the commercial production on the African

[8] USDA RMA 2016, Loss Adjustment Policy & Procedure Support for the Rice BPA, Statement of Work, Task Order #1: Tillering Factors for Rice, page 3 of 5.

[9] Louisiana State University Agricultural Center, 2015, Rice Varieties and Management Tips 2015, http://www.lsuagcenter.com/articles/connected/rice-varieties-and-management-tip, accessed March 2016.

[10] Global Rice Science Partnership, 2016, Ricepedia: Growth Phases, http://ricepedia.org/rice-as-a-plant/growth-phases, accessed March 2016.

continent.[11] U.S. production of rice is now almost exclusively of Asian rice,[12] including long, medium, and short grain types.[13] These rice grain length types are defined by the USDA Federal Grain Inspection Service (FGIS) in the Rice Inspection Handbook. FGIS allows the type determinations to be made by "cursory examination" of the sample being inspected unless there is a need for an objective determination. "When a detailed examination [of type] is necessary, [inspectors] measure the length and width of 15 unbroken kernels taken at random from the work sample and determine their average length-width ratio."[14] Since the hull and bran contribute disproportionately to length as compared to their contribution to width, FGIS has established slightly different length to width ratio standards for rough rice,[15] brown rice,[16] and milled rice[17] (Table 1).

Table 1. Length to Width Ratios of Rough, Brown, and Milled Long, Medium, and Short Grain Rice Required by USDA Grain Standards

Rough Rice[1]	
Long	3.4 to 1 and more
Medium	2.3 to 3.3 to 1
Short	2.2 to 1 and less
Brown Rice[2]	
Long	3.1 to 1 and more
Medium	2.1 to 3.0 to 1
Short	2.0 to 1 and less
Milled Rice[3]	
Long	3.0 to 1 and more
Medium	2.0 to 2.9 to 1
Short	1.9 to 1 and less

[1] USDA, FGIS, 2014, Rice Inspection Handbook, Chapter 3, page 3-6.
[2] USDA, FGIS, 2014, Rice Inspection Handbook, Chapter 4, page 4-6.
[3] USDA, FGIS, 2014, Rice Inspection Handbook, Chapter 5, page 5-6.

Like most grasses grown as crop plants (as opposed to those grown grass species for horticultural uses) rice is grown for its fruit. The fruit are derived from small wind-pollinated flowers borne on a branched[18] arching to pendulous inflorescence 12 to 20 inches long. The technical name for this type of inflorescence is a panicle. In the literature, the term panicle is frequently used for the structure bearing the fruits of the rice plants. The fruit is a caryopsis, the typical fruit of grasses.[19] The entire fruit (rough rice) can be used for feed. The portions of the fruit that cannot be digested by humans are removed by milling to produce the rice used as a food (brown and milled rice).

[11] Linares, O.F., 2007, African rice (*Oryza glaberrima*): History and future potential, Proceedings of the National Academy of Sciences, 99: 16,360–16,365, http://www.pnas.org/content/99/25/16360.full, accessed April 2016.
[12] *O. glaberrima* is grown in the United States primarily as the subject of academic research projects.
[13] USDA FGIS uses the term "type" when characterizing the ratio of length to width of the rice fruits and/or seeds. The FGIS uses the term "class" when characterizing these ratios and describing the extent of breakage and contamination by other types..
[14] USDA, FGIS, 2014, Rice Inspection Handbook, pages 3-6, 4-6, and 5-6 for rough (paddy), brown (hulled), and milled rice, respectively.
[15] Also called paddy rice, this is rice with the hulls intact.
[16] Rice whose hulls have been removed but whose bran is still intact.
[17] Rice whose hulls and bran have been removed.
[18] The branches of the panicle are called spikelets.
[19] Caryopses are commonly called grains, although the term is more ambiguous since it can refer to the fruit, the seed, or the plant producing the fruit.

The key difference between rice and other grain crops is that rice grows readily in standing water or in very wet soil. While rice is a perennial with the potential to produce a harvestable crop in the first and ensuing years, in most developed countries including the United States, rice is grown as an annual. This management approach increases the average annual yield and reduces the yield variability from year to year.

Both inbred and hybrid varieties of *O. sativa* are planted in the United States. The predominate rice varieties grown in the southern states in the United States are long-grain varieties. In these states much of the crop is grown from hybrid seed. In contrast, medium-grain varieties predominate in California fields, where a substantial portion of the crop is still grown from inbred seed.[20] Short grain rice is primarily produced in California. Most states have production of limited quantities of specialty rice appropriate for the locale.

Almost all U.S. rice production is irrigated. The traditional method for cultivating rice is flooding the fields while, or after, setting the seed. This method requires careful planning and careful servicing of the dykes and channels. There is ongoing and promising research into the potential for and implications of sprinkler irrigated rice. While flooding is not an absolute requirement, other methods of irrigation require more weed and pest control.

Hybrid Rice

Like most wind-pollinated species, self-fertilization is common in rice. Historically, rice varieties were inbred because of this self-fertile attribute. After the discovery of *O. sativa* plants with abortive pollen, breeders developed cytoplasmic male sterile (CMS) lines. These lines are bred with maintainer lines (lines that produce the next generation of CMS seed) and separately with fertility-restorer lines for the production of commercial seed. For production of seed for commercial planting, the CMS line is the female parent and the fertility-restorer lines are the male parent. Since three different lines are required for production of commercial quantities of these rice seeds, these hybrids are called “three-line hybrids.”

Grain quality and yield limitations affected the adoption of three-line hybrid rice commercially. The yield limitations of the three-line hybrid varieties are most likely tied to the genetics of the CMS parent. Breeders have overcome some of these limitations and in the United States there has been commercial production of some three-line hybrid varieties, particularly in regions where improved yield and quality have been demonstrated.[21]

In recent years, breeders have developed new-generation hybrid rice varieties that often have a substantial yield advantage over the inbred varieties.[22] Many of these are produced as hybrids from just two-lines. Two-line rice hybridization systems do not require a maintainer line. Under specific photoperiods one line (used as the female line in the hybridization) is male sterile; but

[20] Global Rice Science Partnership, Research Program on Rice, 2013, Rice Almanac, Fourth Edition, page 98, http://books.irri.org/9789712203008_content.pdf, accessed March 2016.

[21] Tran, D.V., and V.N. Nguyen, UN FAO, 1998, International Rice Commission Newsletter, Global hybrid rice: progress, issues and challenges, http://www.fao.org/docrep/003/w8595t/w8595t03.htm#TopOfPage, accessed November 2015.

[22] Louisiana State University Agricultural Center, 2015, Rice Varieties and Management Tips 2015, http://www.lsuagcenter.com/articles/connected/rice-varieties-and-management-tip, accessed March 2016.

sterility of this parent can be controlled by day length. Under appropriate photoperiods this line is self-fertile and is consequently self-maintaining.[23]

Research and development on two-line hybrid rice has focused on greater yields and superior grain quality to those of the three-line hybrids. The two-line hybrid plants tend to be more robust than three-line hybrid plants and the grains produced by the two-line hybrid plants are less fragile than the grains produced by a majority of three-line plants. Consequently, both seed and commercial production of two-line hybrids generally result in greater yields than those of three-line hybrid rice varieties.[24]

Economic Significance of Rice

Rice plays a major role as an agricultural commodity globally, with rice harvested from 208 million of the world's 721 million harvested grain acres in 2014. Only wheat and corn have a larger share of the global harvested grain acres.[25] Overall, the United States exports about half of its rice crop,[26] with 3.5 million tons (3.2 million metric tonnes) of the world's approximately 44 million tons (40 million metric tonnes) of internationally-traded rice exported from the United States in 2013.[27,28] Most U.S. rice exports are of the long-grain varieties and of combined medium and short-grain products. Exports to Mexico and Central America are mostly of rough (unmilled) rice. Exports to northeast Asia, Canada, the Caribbean, the European Union, the Middle East, and Sub-Saharan Africa are primarily of milled rice. A small portion of the rice exported from the United States is of highly processed (parboiled, etc.) rice. These highly processed rice products are exported primarily to developed countries.[29]

Comprehensive agronomic data for the United States are collected by the USDA National Agricultural Statistical Service (NASS) every five years for publication in a Census of Agriculture. This data collection and its analysis provide the "only source of uniform, comprehensive agricultural data for every state and county in the United States."[30] Every farmer and rancher, regardless of the size or type of operation, is expected to participate in the census data collection processes. The last Census of Agriculture data collection occurred for the 2012 crop year. The economic significance of rice production in the United States in 2012, as documented by the Census, is summarized in Table 2. Rice production in 6 principal states accounts for more than 99 percent of the total rice value nationally. The remaining rice produced in the United States that year was grown in Florida (14 farms), Illinois (1 farm), South Carolina (1 farm), and Tennessee (6 farms).[31] According to NASS estimates for the 2015 crop year, rice production in the United States was valued at $2.6 billion.[32]

[23] However, the seed resulting from the propagation of these self-maintaining lines produced when the plants are self-fertile are inbred. Consequently the self-maintaining lines are used as both female parent plants for hybridization and both parents in the production of the next generation of these female parent plants.
[24] *Ibid*.
[25] UN FAO, 2014, FAOSTATS, http://faostat3.fao.org/compare/E, accessed March 2016.
[26] USDA, ERS, 2015, Rice, http://www.ers.usda.gov/topics/crops/rice/trade.aspx, accessed November 2015.
[27] The most recent year for which data are available.
[28] UN FAO, 2016, FAOSTATS, http://faostat3.fao.org/browse/T/TP/E, accessed March 2016.
[29] USDA, ERS, 2015, Rice, http://www.ers.usda.gov/topics/crops/rice/trade.aspx, accessed November 2015.
[30] USDA, NASS, Census of Agriculture, 2015, About the Census, https://www.agcensus.usda.gov/About_the_Census/, accessed November 2015.
[31] USDA, NASS 2012 Census of Agriculture, state level data accessed through Quick Stats.
[32] USDA, NASS, 2015, Quick Stats https://quickstats.nass.usda.gov/results/D635F46F-3758-34A8-9C2B-30039EB26A5C, accessed April 2016.

Table 2. Economic Significance of Rice in the Major U.S. Producing States in 2012 as Compared to All U.S. Agricultural Production

States with Significant Rice Production	Number of Farms	Total Land in Farms	Agricultural Production ($)
	All Farms and Cropland		
Arkansas	45,071	13,810,786	9,775,758,000
California	77,857	25,569,001	42,627,472,000
Louisiana	28,093	7,900,864	3,809,401,000
Mississippi	38,076	10,931,080	6,441,025,000
Missouri	99,171	28,266,137	9,164,886,000
Texas	248,809	130,153,438	25,375,581,000
	Rice		
Arkansas	2,345	1,291,000	1,314,526,000
California	1,391	562,000	782,644,000
Louisiana	822	402,000	363,783,000
Mississippi	259	130,000	131,278,000
Missouri	385	180,000	151,731,000
Texas	361	135,000	136,187,000

Source: After USDA-NASS 2012 Census of Agriculture, state level data accessed through Quick Stats except for planted acreage which is from USDA-NASS 2012 survey data accessed through Quick Stats.

The rice grown in the four states with very limited production is destined for local and specialty markets.[33] Most rice grown in Florida is produced in Palm Beach and Hendry Counties in the Everglades Agricultural Area Environmental Protection District (EAA). Due to the long growing season in these counties, rice can be harvested twice with the second ratoon crop producing a somewhat lower yield than the initial harvest. The rich organic soils where the Florida crop is grown raise the rice protein levels for both those harvests as compared to the levels of protein in rice harvested in other states. The Florida rice crops provide substantial amounts of biomass to the fields, which improves both soil tilth and drainage. The improved soils can result in higher sugarcane yields.[34]

Rice has been grown in Arkansas, Louisiana, and Texas since the mid-19th Century. Commercial rice production in California began in the early 20th Century. In recent years, U.S. rice production has increased, especially in Arkansas, Mississippi, and Missouri. Nonetheless, California now produces the second-largest rice crop in the United States after Arkansas. While more than 100 varieties of rice are grown world-wide, approximately 20 are produced commercially in the United States in any given year. Varieties produced in all regions change from year to year as better seed is developed (See Appendix A).[35]

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[33] Agrilicious SPC, 2016, Local Rice in Tennessee, http://www.agrilicious.org/local/rice/tennessee, accessed April 2016; Carolina Plantation, 2014, The only colonial plantation to still offer rice in the Carolinas, http://www.carolinaplantationrice.com/index/, accessed April 2016.

[34] Palm Beach County, 2016, General Information Rice, http://www.pbcgov.com/coextension/agriculture/sugarcane/information/rice.htm, accessed April 2016.

[35] USDA, ERS, 2015, Rice, http://www.ers.usda.gov/topics/crops/rice/trade.aspx, accessed November 2015; Louisiana State University Agricultural Center, 2014, Rice Varieties and Management Tips 2014, http://www.lsuagcenter.com/NR/rdonlyres/97DE9091-DFAE-46AD-846A-63B1B12512FB/94855/pub2270RiceVarieties2014.pdf, accessed March 2016.; Louisiana State University Agricultural Center, 2015, Rice Varieties and Management Tips 2015, http://www.lsuagcenter.com/~/media/system/8/6/4/0/864051f436294bf5e337d225dc5aad81/pub2270ricevarieties2015final.pdf, accessed March 2016..

Loss Adjustment
"Loss adjustment" is the process for establishing the appropriate indemnity payment to address an insured loss. The USDA RMA Loss Adjustment Manual (LAM) Standards Handbook (25010-1H) "identifies loss adjustment standards and requirements for determining production or revenue and adjusting crop insurance claims in a uniform and timely manner."[36] The LAM documents general requirements for loss adjustment and for completing policy-related inspections (including appraisals). The Rice LASH (Attachment I, found at http://www.rma.usda.gov/handbooks/25000/2014/14_25410-2h.pdf) includes specific crop appraisal methods, claims completion instructions, and form standards, and supplement the standards identified in the LAM. The Rice LASH details specific standards for adjusting losses for rice.[37] All Approved Insurance Providers (AIPs) use these Rice LASH standards for both loss adjustment and loss adjustment training.

The tiller factor plays a role in rice appraisals for loss adjustment made before heading while tillering is not yet complete (tillering incomplete). The tiller factor is multiplied by a count of viable plants in a sample to establish the potential number of plant seed heads (and eventually of grains) likely to develop if the crop were appropriately maintained. Inasmuch as the tiller factor is used in the calculations to estimate potential production when the crop has been damaged prior to producing tillers, if the tiller factor is too small, the appraised production to count for early season losses is under-estimated. Under these circumstances, any indemnity based on the appraised production to count will be too large. Furthermore, the tiller factor is used in assessing the potential production in a damaged field to determine if a replanting payment should be made. If the tiller factor is too small, replanting payments will be made when they are not justified. Conversely, if the tiller factor is too large and an early season loss occurs, the apprised production to count is over-estimated and the amount of any indemnity will too small. Moreover, under these circumstances a replanting payment that is justified by the biological condition of the crop may be withheld. A detailed analysis of the Rice LASH is provided in a separate section of this report.

Rice Crop Insurance History
The Agriculture and Consumer Protection Act of 1973 and the Rice Production Act of 1975 authorized a permanent disaster payment program for rice. The acts provided a system for payments in response to a specific disaster without the need for Congressional action. The program was reauthorized in the Food and Agriculture Act of 1977. The 1980 Federal Crop Insurance Act ended the standing disaster payment program over concerns about its growing cost and the performance of the program.[38]

Under the Federal Crop Insurance Program, both individual and area-based yield and revenue crop insurance products are available for rice producers. Nonetheless, historically crop insurance participation by rice producers was lower than for other grain crops. This lower participation resulted from two factors: historically participation in the entire crop insurance program in the

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[36] USDA, RMA, 2015, 25000 –Loss Adjustment Standards, http://www.rma.usda.gov/handbooks/25000/index.html, accessed November 2015.
[37] See for example USDA, RMA, 2013, Rice Loss Adjustment Standards Handbook, 2014 and Succeeding Crop Years, FCIC-25410-2 (11-2013), http://www.rma.usda.gov/handbooks/25000/2014/14_25410-2h.pdf, accessed November 2015.
[38] The Environmental Working Group, 2016, Crop Insurance: History of Disaster and-Crop-Insurance Programs, http://www.ewg.org/research/crop-insurance/history-disaster-and-crop-insurance-programs, accessed March 2016.

areas where rice is grown was lower than for other regions; and as an irrigated crop, rice yield variability tends to be low. The low yield variability results in infrequent triggering of indemnifiable losses.

Nonetheless, participation by rice producers has increased in the past several years and in 2012, approximately 80 percent of the NASS Census reported planted acres were insured according the RMA's summary of business. However, the Contractor notes producers insuring rice purchase less additional coverage insurance than producers growing other grain crops. Table 3 summarizes the insurance experience for all RMA insurance products for rice in the major rice-producing states over the last ten years.

Table 3. Experience for Rice Crop Insurance in the Major Production States

Year	All Arkansas Rice Products				All California Rice Products			
	Total Liability ($)	Total Premium ($)	Total Indemnity ($)	Loss Ratio	Total Liability ($)	Total Premium ($)	Total Indemnity ($)	Loss Ratio
2006	160,355,022	7,824,800	2,443,785	0.312	113,615,071	4,941,231	8,757,732	1.772
2007	187,351,780	9,045,843	1,488,424	0.165	143,654,345	5,799,099	4,029,206	0.695
2008	252,975,793	11,952,179	4,566,027	0.382	161,603,485	5,980,189	936,258	0.157
2009	360,666,504	20,564,298	17,884,218	0.870	281,079,079	11,726,058	2,460,057	0.210
2010	510,497,069	30,395,568	19,528,458	0.642	223,123,008	7,959,709	2,667,144	0.335
2011	448,858,758	27,541,428	62,369,670	2.265	304,408,440	10,395,787	2,409,687	0.232
2012	421,798,241	22,534,525	3,229,333	0.143	282,377,325	9,784,628	1,184,976	0.121
2013	494,091,094	27,242,516	64,069,669	2.352	296,402,931	8,419,394	3,323,878	0.395
2014	668,688,932	37,780,679	33,208,253	0.879	543,828,788	23,408,594	50,485,136	2.157
2015	607,170,218	29,508,750	65,007,040	2.203	434,643,326	15,713,267	55,209,677	3.514
Year	All Louisiana Rice Products				All Mississippi Rice Products			
	Total Liability ($)	Total Premium ($)	Total Indemnity ($)	Loss Ratio	Total Liability ($)	Total Premium ($)	Total Indemnity ($)	Loss Ratio
2006	64,380,050	3,729,443	6,174,129	1.656	34,772,310	1,578,257	144,494	0.092
2007	79,772,235	4,197,084	796,984	0.190	42,373,126	1,893,718	339,412	0.179
2008	116,016,097	5,830,427	5,454,034	0.935	66,586,714	3,005,900	1,852,220	0.616
2009	163,114,643	9,805,732	10,365,187	1.057	110,342,719	7,538,684	8,410,598	1.116
2010	180,940,611	10,655,699	4,482,836	0.421	151,412,534	9,986,048	5,497,235	0.550
2011	170,989,174	8,251,293	5,308,157	0.643	84,706,019	5,255,197	3,903,146	0.743
2012	162,276,296	7,361,868	2,486,139	0.338	63,104,343	3,440,602	1,097,490	0.319
2013	194,677,788	7,866,863	1,951,903	0.248	83,721,212	5,035,438	9,616,558	1.910
2014	228,857,478	9,911,529	3,435,099	0.347	112,656,462	5,838,775	6,542,350	1.121
2015	179,977,208	6,504,931	7,433,573	1.143	88,450,285	3,438,967	6,452,207	1.876
Year	All Missouri Rice Products				All Texas Rice Products			
	Total Liability ($)	Total Premium ($)	Total Indemnity ($)	Loss Ratio	Total Liability ($)	Total Premium ($)	Total Indemnity ($)	Loss Ratio
2006	21,925,511	1,632,100	736,375	0.451	38,617,384	1,855,904	1,291,464	0.696
2007	22,670,956	1,673,316	380,139	0.227	48,165,124	2,325,015	1,846,077	0.794
2008	34,739,265	2,557,875	300,361	0.117	66,256,263	3,089,684	2,511,226	0.813
2009	53,430,749	4,400,277	2,061,981	0.469	88,083,878	5,044,994	4,438,131	0.880
2010	67,299,919	5,370,338	950,277	0.177	88,345,782	4,748,967	1,565,694	0.330
2011	60,342,801	5,059,326	13,295,876	2.628	96,085,035	5,212,679	2,725,882	0.523
2012	62,803,913	4,069,538	1,001,995	0.246	101,328,718	7,706,240	32,257,129	4.186
2013	77,905,894	5,294,777	7,846,813	1.482	130,007,098	8,599,958	36,864,930	4.287
2014	94,160,199	6,874,467	4,833,431	0.703	128,872,170	9,571,026	43,612,141	4.557
2015	78,106,300	5,332,955	8,343,679	1.565	113,534,564	8,366,743	44,859,561	5.362

Source: After USDA-RMA, 2015 Summary of Business data accessed through the Summary of Business report Generator website.

There is no pattern of indemnities or loss ratios that suggests a fundamental weakness in the Rice Crop Insurance Program. The substantial loss years recently in California and Texas reflect years of major droughts and associated impacts on irrigation water availability. In California, with its substantial plantings of inbred rice, the loss ratios over time are not substantially different from the loss ratios in the southern states other than Texas. Hybrid rice varieties predominate in these south central regions. A full evaluation of the rice crop insurance program is beyond the scope of the work required under this TO.

III. RICE LOSS ADJUSTMENT STANDARDS

This section of the Deliverable responds to the requirement in the SOW which states: "The contractor shall review and analyze the Rice LASH [Loss Adjustment Standards Handbook] to demonstrate understanding of the appraisal methods including the following [sic] specific procedures that apply a tiller factor during the appraisal process"[39]

An appraisal is "an estimate or considered opinion."[40] In the context of crop insurance, it is an estimate developed from the facts concerning the condition of a crop in a field as determined to exist by the loss adjuster. Those facts then are converted into an estimate of the amount of production lost by means of parameters that reflect expectations regarding the probable development of the crop from its current condition until maturity. The tiller factor is one of those parameters. The appraisal process for crops insured under the Small Grains Provisions (barley, oats, rye, and wheat) and for rice are performed before tillering is complete is summarized in Table 4.[41]

Table 4. Steps Involved in Performing an Appraisal of Acreage of Rice and Other Small Grains and the Output of Each Step*

Step	Output
Determine number of live plants in 10 feet of row length	The estimated number of plants capable of producing tillers.
Average the number of live plants in all sample rows	The average number of plants capable of producing tillers as determined from the required number of samples.[42]
Multiply average number of live plants by the tiller factor	The estimated number of plants that will exist after tillering is complete (result from second step multiplied by 2.5 for rice).
Divide estimated number of tillers by the square foot factor	The estimated number of tillers per square foot of area. Square foot factor is an arithmetic result determined by the row width and the square feet in an acre.
Multiply estimated tillers per square foot by tiller to pounds yield factor	The estimated number of pounds of grain production per acre. Tiller to pounds yield factor differs by type of rice.

Source: USDA, RMA, 2013, Rice Loss Adjustment Standards Handbook (FCIC-25410-2 (11-2013) and USDA, RMA, 2015, Small Grains Loss Adjustment Standards Handbook (FCIC-25430-2 (06-2015).

* The Contractor notes "tiller" is not defined in the Rice LASH, the LAM or CIH. The Rice LASH use of the term does not differentiate among plants originating from the seedling, primary tillers, and secondary tillers as used in the biological and agronomic literature. Consequently, the yield potential from each of these sources is assumed to be the same. Biologically, a tiller is a branch that forms from axillary buds on the main stem of the plant once that stem has produced four to five leaves. These branches can form differentially depending on a number of causes. Some of these branches, especially in the earliest stages of development, have the potential to produce seed.

The number of tillers produced per surviving seed directly affects the potential production of the field because that parameter affects the number of panicles (i.e., flowers clusters) and ultimately the number of filled grains produced per unit of area (see the discussion on yield in the following Section). The estimated weight of the seeds that will be produced per head can be converted to total pounds of production per acre.

[39] USDA, RMA, 2016. Solicitation for Rice Loss BPA (Loss Adjustment Policy & Procedure Support for the Rice BPA, Statement of Work: Tillering Factors for Hybrid Rice, page 3 of 5.

[40] Houghton Mifflin Harcourt Publishing Company, 2014, The Free Dictionary by Farlex, http://www.thefreedictionary.com/appraisal, accessed March 2016.

[41] An appraisal may involve both fields where tillering is incomplete and fields where tillering is complete, depending on the condition of the field. This discussion focuses solely on the process for fields where tillering is incomplete.

[42] The required number of samples is based on field size and uniformity of the surviving stand of rice.

The Rice LASH advises the loss adjuster as follows regarding appraisals for damage other than hail when tillering is incomplete: "WHENEVER POSSIBLE, delay appraisals when damage occurs before tillering is complete and the number of live plants capable of producing rice cannot be identified. Use judgment as to the number of tillers that will produce a normal head" (section 6B(2)(a), emphasis in the original). However, the Contractor notes delay is not always possible. When a loss should be indemnified with replanting payments is one situation in which an appraisal cannot be delayed until tillering is complete. The determination that acreage qualifies for a replanting payment is based on an assessment that the remaining stand in the area where the crop is damaged will not produce at least 90 percent of the production guarantee (0.90 x APH approved yield x coverage level factor). In general, producers most likely want to replant damaged acreage before the final planting date, not wait until the initially planted (damaged) acreage produces tillers.

Table 4 shows the tiller factor is one of the two biological parameters that establish an appraised amount of production per acre for pre-tillering appraisals. The other biological parameter is the tiller to pounds yield factor from Table D in the LASH. The tiller to pounds yield factor currently is 120 pounds per acre for all varieties of short and medium grain rice and 105 pounds for all varieties of long grain rice.

However, if the appraisal is performed after heading, an average count of kernels per square foot to pounds per acre yield factor (Table E) is included in the appraisal process. This factor varies significantly by variety within type and is based on the average weight of kernels for the variety. While the Contractor does not believe it is reasonable to assess a constant tiller to pounds yield factor within type before heading and a yield factor that is variable by variety within type after heading, any investigation into the tiller to pounds yield factor or the average kernels per square foot to pounds per acre yield factor is outside the scope of the SOW.

The Contractor reviewed section 6B(2) (Before Heading Appraisals – Tillering Incomplete) and section 8C (Worksheet Entries and Completion Information) Part I (Before Heading) of the Rice LASH to evaluate the degree to which the procedures are "… implemented efficiently and do not impose unwarranted burdens and costs on producers, AIPs and the government." The Contractor found that sub-sections 6B(2)(b) and (c) are somewhat opaque with respect to the directives to the loss adjuster. "Using the tiller factor from TABLE C, convert single plant counts to tillers to count" (sub-section 6B(2)(b)). Convert how? By multiplication? By division? By exponentiation? Similarly, sub-section 6B(2)(c) instructs the loss adjuster to "convert." The instructions in sub-section 8C are much more comprehensive, providing details regarding the numbers to be entered in each cell of the worksheet and the arithmetic processes by which subsequent entries are determined. The explanation of the appraisal process may be more efficient if the information in sub-sections 6B(2)(b) and (c) were omitted entirely. A simple declaration in sub-section 6B(2) that the details regarding the appraisal are to be determined by following the process outlined in section 8C would suffice.

The Contractor does not believe these points are sufficient to find that the procedures are not "implemented efficiently" and therefore "impose unwarranted burdens and costs." These are merely points of clarification of procedures. The procedures specified in the identified sections of the LASH are necessary for the proper administration of the crop insurance program. Early season appraisals are a necessary and vital element of the program to enable it to meet the diverse conditions that exist in the circumstances of crop production. The need to determine the right to a replanting payment is a prime example of the need for early season appraisals. Support of a producer's decision that a damaged crop cannot be economically carried to harvest due to the fact that the costs of fertilizer, pesticide, and other inputs as well as of harvest exceed the probable revenue to be realized from harvest (i.e., abandonment of the acreage) is another example of need for early season appraisals. However, the crop insurance program does need to assure that the potential value of any estimated production is recognized prior to payment of an indemnity in the event acreage is abandoned. Thus, there is need for early season appraisals.

The before tillering loss adjustment procedure merely asks the loss adjuster to count the number of live plants in several different samples that are ten feet in length. The number of samples is a function of the number of acres in the field or sub-field: a minimum of three samples for up to 10 acres, plus one additional sample for each 40 acres or fraction thereof. A sample consists of ten consecutive linear feet randomly selected from a randomly selected row of the planted crop. Determining whether a plant is "live" and capable of producing tillers can be a judgement. The Contractor does not believe the requirement constitutes an undue burden given the needs of the crop insurance program.

The Contractor also reviewed the instructions in Section 9C of the LASH (Form Entries and Completion Information) Section I (Determined Acreage, Appraised Production, and Adjustments) item 31 (Appraised Potential). The instructions direct the loss adjuster to enter the potential production for acreage appraised as shown on the appraisal worksheet. However, this instruction applies only for preliminary and final appraisals for loss of production. For replanting payments, the loss adjuster is directed to enter the number of pounds allowed for a replanting payment. The degree to which the acreage failed to meet the 90 percent threshold is not documented in the numerical data captured on the worksheet. That information is included in the Narrative section of the Production Worksheet; however, this treatment does not lend itself to analytical support to determine the appropriate amount of a load for replanting at the various coverage levels.

The Contractor's proposal stated that the Deliverable "will review the loss information from the RMA Type P21 data to see if it contains data about how tillering is impacting the losses for the rice program." A total of 28,583 Type P21 records were found for the years 2003-2014. These records include approximately 3.2 million gross determined acres and $561 million of payments, as shown in Table 5.

Table 5. Descriptions of the Stage of Loss and Number of Determined Acres, Rice, 2003-2014

Stage Description	Determined Acres	Percent	Payments ($)	Percent
Acreage not containing DCE or not qualifying for DCE	19,694	0.6%		0.0%
Denied Claim	3,688	0.1%		0.0%
Harvested	775,950	23.9%	95,318,465	17.0%
Harvested Acreage Qualifying for DCE	101,091	3.1%	6,270,589	1.1%
Not Replanted	324	0.0%		0.0%
NULL	1,954	0.1%	40,799	0.0%
Prevented Planting - Unplanted Acreage	931,790	28.7%	113,021,213	20.1%
Prevented Planting - Unplanted Acreage with 10% Buy Up Option	818,908	25.3%	265,504,249	47.3%
Prevented Planting - Unplanted Acreage with 5% Buy Up Option	1,775	0.1%	425,498	0.1%
Replanted	385,709	11.9%	15,091,790	2.7%
Unharvested	200,400	6.2%	65,601,118	11.7%
Uninsured Loss	304	0.0%		0.0%
Grand Total	3,241,587	100.0%	561,273,721	100.0%

* Records labeled "NULL" stage description occurred for five CAT policies in Poinsett County, AR in 2011. The cause of loss was identified as flood.

Use of the tiller factor is not explicitly identified in the P21 data. The Contractor does not note this omission to be a flaw in the data collected to administer the crop insurance program, but instead is merely noting that absence of this information requires reasonable judgements about which loss records may have involved its use. The only definitive information about potential use of the tiller factor can be found with respect to replanting payments. It is a given that the determination to allow most replanting payments must be based on the early season crop conditions, most likely before tillering has occurred. As demonstrated in Table 5, replanted acres constituted nearly 12 percent of all determined acres but less than 3 percent of all payments to producers during the years 2003-2014.

A higher value than 2.5 for the tiller factor may have disallowed some of the replanting payments. There is no way analytically to determine if this is true because the data included in the type 21 record merely justify the amount allowed, not the decision to make the payment. But, given the magnitude of replanting payments relative to total indemnities, it is evident that a higher factor would not have had a material effect on the overall loss costs of the Rice Crop Insurance Program.

The other source of potentially avoidable payments falls under the stage descriptor "Unharvested." The only part of these payments that would be affected is represented by early season losses of such severity that the producer elects to abandon the crop rather than incur further expense for maintaining it to maturity. Accordingly, the producer will file a notice of loss and seek to obtain the consent of the AIP to abandon[43] the acreage.[44] The loss adjuster will appraise the acreage to establish the amount of production that would be expected given normal

[43] Abandon means "failure to continue to care for the crop, providing care so insignificant as to provide no benefit to the crop, or failure to harvest in a timely manner, unless an insured cause of loss prevents you from properly caring for or harvesting the crop or causes damage to it to the extent that most producers of the crop on acreage with similar characteristics in the area would not normally further care for or harvest it" (Common Crop Insurance Policy Basic Provisions, Section 1).

[44] Failure to obtain consent will result in an appraisal of not less than the production guarantee per acre.

crop development to maturity. This appraised amount establishes the amount of production to count. An indemnity may or may not be paid on the basis of the appraisal. If the abandoned acres represent only a portion of a unit, the production from the remainder of the unit will be included in the production to count. However, the acres in stage "UH" are reported separately in the Type P21 records.

The Contractor attempted to estimate the amount of potential loss avoidance that might be achieved if the tiller factor could be increased based on scientific evidence. However, not all the payments to producers that are classified under "Unharvested" are not due to early season, pre-tillering appraisals. Accordingly, the Contractor established criteria to extract Type P21 records that might be included in this limited category. The criteria were:

1. Field 33 (harvested production quantity) must be less than field 34 (production to count quantity).
2. The primary date of damage must be less than 61 days after the date planting was completed.
3. The stage code (field 16) must be "UH" (unharvested).

Field 34 of the Type P21 record determines the amount of the indemnity since that amount is subtracted from the loss guarantee to establish the unit deficiency. The instructions for the Type P21 record state that field 34 "must equal the sum of the Net Harvested, Net Allocated and Net Appraised Production. Adjusted for moisture and quality." The instructions for field 33 state that this value "must be less than or equal to the Production to Count Quantity, otherwise empty." The rationale for using this criterion in establishing the potential loss avoidance that might be achieved if the tiller factor could be increased based on scientific evidence is that any record representing an appraisal will have zero harvested production quantity but a non-zero production to count quantity (the result of the appraisal). A total of 4,536 Type P21 records for the period 2003-2014 were identified by this criterion.

The second criterion is based on agronomic evidence that tillering should be complete by approximately 60 days after the crop is planted.[45] This, of course, is not an iron-clad rule. A diagram in the publication Arkansas Rice Production Handbook[46] (page 10) indicates that tillering can be completed in as little as 44 days under good conditions but completion of tillering may require 89 days under less favorable conditions. A total of 1,867 Type P21 records from the 4,536 identified by the first criterion met this second criterion.

The third criterion identifies those records for which the acreage was not harvested. The second criterion is not sufficient because while damage could have occurred within the 0 – 61 day window it is possible the crop was maintained until harvest. This third criterion identified those records for which the harvested production quantity is less than the production to count quantity and that incurred damage within 60 days of completion of planting and on which the acreage

[45] This represented a generalized phenology for the completion of tillering in mid-season rice presented in Global Rice Science Partnership, Research Program on Rice, 2013, Rice Almanac, Fourth Edition, page 7, http://books.irri.org/9789712203008_content.pdf, accessed March 2016; and in Ricepedia, undated, Growth Phases, http://ricepedia.org/rice-as-a-plant/growth-phases, accessed March 2016.

[46] Arkansas Rice Production Handbook. MP 192. Edited by Jerrod T. Hardke. University of Arkansas Division of Agriculture. Cooperative Extension Service. Little Rock, AR. The diagram in Table H of the LASH appears to be the same as that contained in the Arkansas Rice Production Handbook, but it does not contain the legend indicting number of days.

remained unharvested. A total of 782 records were identified by this criterion. These represented 84,003 determined acres and just under $30 million of indemnities for the 12 years (2003-2014), which equate to approximately 2.5 percent of indemnified acres and 5.3 percent of all payments to producers. The Contractor believes the criteria provide a reasonable approximation to determine the frequency of early season appraisals and the share these represent of indemnities.

Very few changes would be needed in the LASH if one or more additional tiller factors are needed. Table C would be expanded, perhaps by variety (as is the case with Table E). In the simplest case, the expansion would simply separate hybrid types from traditional types, each with a unique tiller factor. In addition, some minor modifications to the instructions contained in Section 6B(2) would be needed. The only intent of these changes would be to emphasize that the appropriate tiller factor is to be extracted from Table C. These observations are applicable only if it is possible to determine an appropriate tiller factor.

IV. DATA COLLECTION

The objective of the first TO under this contract "is to conduct research and determine the appropriate tillering factor(s) for conventional and hybrid rice varieties, which are used while performing rice appraisals…"[47] Ultimately the purpose of the appraisal referenced in the SOW is to obtain an estimate of the amount of production lost. The loss is a function of the expected yield if the field had not experienced a loss and the expected yield for the field affected by the loss if the field were maintained to maturity. The estimate of the expected yield for the field experiencing the loss if the crop were maintained to maturity is determined using a variety of observations as well as parameters published in the Rice LASH.[48] The tiller factor may be one of those parameters depending on the date of the loss and the decision of the producer regarding whether or not to abandon the damaged acreage. The Contractor proposed gathering data on tillering from acceptable data sources to determine whether inbred and hybrid rice varieties have significantly different potential to produce tillers. Due to the nature of the requisite data, the anticipated sources of the data were extension agents involved in rice breeding and production and seed company agronomists whose research might include collection of tillering data.

Despite our extensive data collection efforts, neither seed companies nor extension agents provided data on average numbers of tillers per plant, much less on tillering by variety, locale, or plant density. Ultimately, one expert explained the lack of responses, stating: "The issue I have is why one would consider tiller number at all when looking at potential yield [following a] loss. To the industry, a rice plant includes tillers. We do not look at tillers as separate plants. Using just a plant density measurement [following a loss] would be more uniform and to me a more accurate assessment of yield loss… Most of the universities that conduct rice research have these studies [on plant density correlations with yield] for each variety. Also [plant density] is the industry standard as whether to replant a field or not."[49] Based on this insight, it is reasonable to conclude that the lack of response to the queries was based on the potential that these data simply do not exist.

Recognizing the importance of this observation, the Contractor undertook studies on the literature for rice yields and for tillering to establish if it might be possible to determine the appropriate tiller factor(s) for conventional and hybrid rice varieties from this literature or if it might be feasible to conduct field trials to establish the appropriate tiller factor values. The results of these research efforts are presented in the two sections that follow.

[47] USDA, RMA, 2016. Solicitation for Rice Loss BPA (Loss Adjustment Policy & Procedure Support for the Rice BPA), Statement of Work: Tillering Factors for Hybrid Rice, page 2 of 5.
[48] The actual process used for loss adjustment for early season loses for rice is described in more detail in the preceding section.
[49] Dr. S. Bottoms, Technical Services Director, Horizon Ag. Horizon Ag has created unique partnerships with technology providers, seed companies and universities to brings novel seed technologies and advanced germplasm for rice to market.

V. COMPONENTS AFFECTING RICE YIELDS

Ultimately, crop insurance for both yield and most revenue products is based on yields, requires an assessment of yields actually realized and yield potential. Luis Espino, Rice Farm Advisor and Chair of the Rice Workgroup at the University of California, describes the contributions of various yield components of rice with the following formula:

YIELD (weight/unit area) = Panicles/unit area X number of spikelets/panicle X number of filled grains/spikelet X kernel weight[50]

The reader will note, tillering is not an element of Espino's formula. Yet tillering is an important element of the architecture of plants in the genus *Oryza*. Tillering assures that a seedling ultimately produces sufficient foliage to capture an optimal amount of the insolation impacting the location where the plant is growing. In other words, tillers generally ensure the formation of dense foliage and development of multiple seed heads (panicles).

It should be noted tillering rates are heavily influenced by environmental attributes. For example, when soil moisture is low, grasses tend to develop deep root systems instead of broad lateral stem systems. Under these circumstances tillering is inhibited. However, because all insured rice is irrigated, as long as the insured maintains an appropriate irrigated practice as defined in the Document and Supplemental Standards Handbook (FCIC-24040 (06-2015)), the tillering of FCIC insured rice should not be limited by soil moisture.

While Espino's formula provides a reasonable mechanism for a producer to understand the general elements of the plant's architecture contributing to yield, for the purposes of analyzing the tiller factor, it is important to recognize that panicles can form either from main culm (the primary stem growing directly from the seedling) or from tillers; that not all tillers are productive (i.e., producing panicles); that the number of spikelets on a primary panicle is likely to be larger than the number on a panicle forming from a tiller; and that the number of filled grains is potentially different from one panicle to another.

Tillering in rice begins during the vegetative stage of rice development after the fourth true leaf is fully emerged. The nodes during this stage are close to the ground with very short internodes. While at this stage it appears a whorl of leaves develops at a single node, in fact each leaf develops from a separate node that has the potential to produce both a primary tiller and a root. Each node has an axillary meristem. The meristem producing the tiller at the first node is released from inhibition when the fourth leaf emerges. When the fifth leaf emerges, the meristem at the second node is released from inhibition, and so on. Tillers emerging in this way from nodes in the main stem are called primary tillers. Consequently the potential for development of primary tillers is only limited by the number of leaves that develop in the compressed (i.e., vegetative) growth stage. It is common that there are five leaves in this compressed region of the stem, which would provide the potential to form five tillers. However,

[50] Espino, L., 2014, Rice Yield Components, UC Rice Blog: California Rice Production, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=14826, accessed February 2016.

the number of tillers that actually develops is influenced by available light (which includes shading from competition), nutrients, and available moisture.[51]

Primary tillers development stops when the panicle on the plant begins development. This marks the start of the reproductive phase. At this point, tillers called secondary tillers can branch out from preexisting tillers, filling most or all the space in the field not shaded by plants.[52]

The number of panicles in a unit area (usually per foot^2 in the U.S. literature on tillering) is therefore determined by both the number of established seedlings and the number tillers produced by each established seedling. In a stand with 15 to 20 plants/ft^2, each plant will produce one to 3 tillers on average. This number is comparable to the tiller factor in the current Rice LASH. However, when a stand has only 5 to 7 plants/ft^2, each plant may produce up to dozen tillers, including both primary and secondary tillers.[53] Fageria in his treatise on rice yield physiology noted: "I have always been amazed at the capacity of rice plants to adapt to the conditions of the field, producing more tillers in thin stands and less tillers in dense stands. [Furthermore] tillering is one of the important stages that can be most influenced by management practices."[54]

While numerous factors affect the development of productive (i.e., grain producing) tillers, from the perspective of publishing a tiller factor for use in insurance adjustment, it appears the most important is the role of stand density. As the stand density increases from 10 to over 40 per foot^2, the number of productive tillers per plant decreases by as much as 60 percent, while the yield per unit area may simultaneously increase (although not in a linear fashion).[55] A typical recommendation for stand density for rice is 15 to 25 plants per foot^2.[56]

However, the tiller factor is used to adjust losses of vegetative plants. In other words, the tiller factor is used to adjust losses after a stand density has been reduced. Consequently, stand densities of less than 15 per foot^2, and perhaps much less than 15 per foot^2 must be considered. By extrapolation of the values presented in the 2012 Espino report, at a plant density of 5 per foot^2 as many as 7.5 productive tillers per plant might be expected and as the plant number per square foot decreases below that level, the surviving plants could be expected to produce a number of tillers limited only by their biological potential.

[51] Moldenhauer, K., C.E. Wilson Jr., P. Counce, and J. Hardke, University of Arkansas Division of Agriculture Cooperative Extension Service, 2013, Arkansas Rice Production Handbook: Rice Growth and Development, J.T. Hardke, Editor, pages 9-20.

[52] Espino, L., 2012, Rice Tillering, UC Rice Blog: California Rice Production, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=7779, accessed February 2016; Linscombe, S., 2012, Understanding of Growth Stages is Critical in Rice Production, http://www.lsuagcenter.com/portals/our_offices/research_stations/rice/features/publications/understanding-of-growth-stages-is-critical-in-rice-production, accessed April 2016.

[53] Espino, L., 2014, Rice Yield Components, UC Rice Blog: California Rice Production, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=14826, accessed February 2016.

[54] Fageria, N.K., 2007, Yield Physiology of Rice, Journal of Plant Nutrition 30:843-879.

[55] Espino, L., 2012, Rice Tillering, UC Rice Blog: California Rice Production, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=7779, accessed February 2016.

[56] Runsick, S., and C.E. Wilson Jr., 2014, Rice Tillering, Rice Seeding Rate: Recommendations for Arkansas, https://www.uaex.edu/publications/PDF/FSA-2157.pdf, accessed April 2016; University of California Rice On-line, 2016, Seeding Rate Calculator, http://rice.ucanr.edu/Rice_Calculator/, accessed April 2016.

For most rice plants almost all the vegetative nodes have the potential to produce a tiller, but only at the appropriate time in the vegetative cycle. Therefore, for an early season loss, 10 to 15 tillers might form as there may be as many as 15 vegetative nodes and the tillers themselves have nodes that can produce productive tillers. But for losses closer to the end of the vegetative stage, the tillering "recovery" might not exceed the 2 to 4 typically expected since the older nodes have passed the period when the tillering potential can be realized.[57] Consequently, lower plant densities resulting from an early season loss are not likely to result in proportional yield reductions as increased tillering compensates for substantial portions of the loss. In contrast, tillering of plants in fields where losses occur closer to heading is less likely to compensate for the losses.[58]

The SOW in the Solicitation for this TO states:

> *The recommended seedling population for hybrid rice varieties (8-10 per sq. ft. in Louisiana and 9-12 per sq. ft. in Mississippi) is about one-half of the recommended population of conventional rice varieties (10-20 per sq. ft. in Arkansas, 15-25 per sq. ft. in Louisiana, and 12-20 per sq. ft. in Mississippi). This is due to the practice of hybrid rice profuse tillering."*[59]

However, it is not the seeding rate, but the stand density that ultimately determines yields in fields that have not experienced a post-germination loss. Recognizing the impacts of tillering described above, Espino's yield component formula can be expanded to better illustrate the role of tillers on yield as:

> YIELD (weight/unit area) = Plants from seed/area X ((Panicles/primary stem[60] X
> number of spikelets on panicles/ primary panicle X
> number of filled grains/primary panicle spikelet) + (productive tiller/plant X
> panicles/productive tiller X number of spikelets from productive tiller/panicle X
> number of filled grains/tiller panicle spikelet)) X (kernel weight)[61]

However, this construct for determining yield or yield potential in the case of an insurable loss event is too complex to provide a basis for loss adjustment. Therefore the Contractor sought to determine if the published literature on tillering alone would support a establishment of one or more tiller factors for inbred and hybrid rice independent of the yield data.

[57] Mohapatra, P.K., R. Patel and S.K. Sahu, 1993, Time of Flowering Affects Grain Quality and Spikelet Partitioning within the Rice Panicle, Australian Journal of Plant Physiology 20:231 – 241; Moldenhauer, K., C.E. Wilson Jr., P. Counce, and J.T. Hardke, 2014, Rice Growth and Development, Arkansas Rice Production Handbook, pp. 9-20.

[58] Jarrod Hardke, J., 2016, Arkansas Rice Update, http://www.arkansas-crops.com/2016/04/15/arkansas-rice-update-15-16/, accessed June 2016.

[59] USDA, RMA, 2016. Solicitation for Rice Loss BPA (Loss Adjustment Policy & Procedure Support for the Rice BPA), Statement of Work: Tillering Factors for Hybrid Rice, page 2 of 5.

[60] Primary panicle.

[61] Fageria, N.K., 2007, Yield Physiology of Rice, Journal of Plant Nutrition 30:843-879; Espino, L., 2014, Rice Yield Components, UC Rice Blog: California Rice Production, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=14826, accessed February 2016.

VI. RICE TILLERING

This section addresses the question: does the tillering pattern described in the literature support the development of tiller factors that could be used to establish yield potential such that:

> YIELD (weight/unit area) = Plants/area X tiller factor (panicles/area) X grain factor (kernels per panicle) X kernel weight[62]

The reader will note the similarity of this simplification of the yield formulae presented earlier to the calculations used in the appraisal process for rice losses that occur prior to the completion of tillering.

As noted earlier, the rice seedling produces a primary stem using energy stored in the seed. Once the primary stem has in turn produced four to five leaves, it becomes self-supporting, no longer dependent on the energy stored in the seed. Depending on a number of causes, branches can develop from the main stem. Some of these branches, especially in the earliest stages of development, have the potential to produce seed. Branches with this attribute in rice are called tillers. Although most tillers remain attached to the plant from which they develop, they produce their own roots and can consequently behave physiologically as independent entities. Regardless of whether the tillers form these independent entities or remain dependent on their "parent" plant, they contribute to an increased yield as compared to the yields of plants with fewer tillers. However, the extent of the contribution under these two different circumstances may differ.

The amount of tillering, the development of flowers on the tillers, and the development of grains from those flowers all depend on the variety of genetic and environmental factors. In rice breeding programs, several genetic traits are selected to increase yield potential. The yield of rice involves three main components: number of panicles per unit area, number of spikelets per panicle, and kernel weight.[63] These components contribute to grain yield to differing extents and the contribution of these three components varies with genotype, environmental factors and cultivation practice. Plant architecture is in turn affected by these three factors. Rice plant architecture is a composite of tiller pattern, plant height, leaf shape and arrangement, and panicle architecture. Of these, tiller pattern (including tiller number) is the most affected by environmental factors, with the density of the stand being a major factor affecting architecture.[64]

The branching that produces tillers is influenced by the frequency of branching, the nature of the branches (i.e., whether they are destined to be vegetative or reproductive), and the angle of branches. Together these determine the amount of space occupied by the branches and the amount of light that can be collected for photosynthesis. When a tiller forms, the axillary meristems grow out to form branches that are similar in to the main stem (culm) and consequently have a similar (but not identical yield potential) to the main culm. In this way, tillering is directly linked to the number of panicles, which in many cases is the most important

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[62] Fageria, N.K., 2007, Yield Physiology of Rice, Journal of Plant Nutrition 30:843-879; Espino, L., 2014, Rice Yield Components, UC Rice Blog: California Rice Production, http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=14826, accessed February 2016.

[63] Peng, S., R.C. Laza, R.M. Visperas, A.L. Sanico, K.L. Cassman, and G.S. Khush, 2000, Grain yield of rice cultivars and lines developed in Philippines since 1996, Crop Science 40: 307–314.

[64] Yang, X-C. and C-M Hwa, 2008, Genetic modification of plant architecture and variety improvement in rice, Heredity 101: 396–404, http://www.nature.com/hdy/journal/v101/n5/full/hdy200890a.html#bib35, accessed April 2016.

basis of yield. The grain weight is under much stronger genetic control. The number of tillers is influenced by numerous environmental factors, which are limited by the genetic potential of the rice.[65]

Genetics, which is the basis of breeding programs, does influence tillering in rice. Mutations have been identified that affect the number of tillers, the location of tiller potential, and the tiller angle, although not all these factors are affected by a single gene.[66] Furthermore there are gene interactions, including interactions that can be affected by whether the plant is inbred or hybrid. The growth of axillary meristems into branches in some plants is controlled primarily by plant growth hormones.[67] Although similar control has not been demonstrated in rice, other genetic patterns in rice regarding both branching and height are similar to those of the plants where these mutations have been identified. [68] Finally, other aspects of the rice architecture have been shown to have typical patterns of hormonal control.[69]

As noted earlier, the angle between the main stem and its tillers contributes to the agronomic performance of rice.[70] While the potential angle is influenced by genes considered in breeding programs, the actual angle of a branch is also impacted by the stand density and especially by shading. Consequently a stand in a loss unit is likely to have tiller angles quite different from those in a full stand.

Domesticated varieties of rice are less branched than their wild progenitors allowing closer planting and less self-shading.[71] Normally, commercial rice plants do not have higher branches where the stem internodes elongation has occurred. Some mutants produce fewer tillers where the stem internodes have not expanded.[72] These would result in varieties that are more compact and because of the limited tillering would have a lower tiller factor. Others mutations identified in *Oryza* species (but not yet in Asian rice) produce a creeping habit where the tiller angle results in greater expansion of the plant complex into un-shaded areas. Variation of tillers angles of *O. rufipogon* is depends on water availability and position in the stand relative to other rice plants.[73]

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[65] *Ibid*.

[66] Li, X., Q. Qian, Z. Fu, Y. Wang, G. Xiong, D. Zeng, W. Xiaoqun, L. Xinfang, T. Sheng, H. Fujimoto, Y. Ming, L. Da, H. Bin, and L. Jiayang Li, 2003, Control of tillering in rice, Nature 422: 618–621.

[67] Bennett, T., T. Sieberer, B. Willett, J. Booker, C. Luschnig, and O. Leyser, 2006, The ArabidopsisMAX pathway controls shoot branching by regulating auxin transport. Curr Biol 16: 553–563, http://ac.els-cdn.com/S0960982206011195/1-s2.0-S0960982206011195-main.pdf?_tid=6511e7de-07d8-11e6-98ed-00000aacb35e&acdnat=1461253847_5606564f00a9e9bfd33af897114568bc, accessed April 2016.

[68] Yang, X-C. and C-M Hwa, 2008, Genetic modification of plant architecture and variety improvement in rice, Heredity 101: 396–404, http://www.nature.com/hdy/journal/v101/n5/full/hdy200890a.html#bib35, accessed April 2016.

[69] Ishikawa, S., M. Maekawa, T. Arite, K.Onishi, I. Takamure, and J. Kyozuka, 2005, Suppression of tiller bud activity in tillering dwarf mutants of rice, Plant Cell Physiology 46: 79–86, http://pcp.oxfordjournals.org/content/46/1/79.full.pdf+html, accessed April 2016.

[70] Xu, Y., S.R. McCouch and Z. Shen, 1998, Transgressive segregation of tiller angle in rice caused by complementary gene action, Crop Science 38: 12–19.

[71] Doust, A., 2007, Architectural evolution and its implications for domestication in grasses. *Annals of Botany (London)* **100**: 941–950, http://aob.oxfordjournals.org/content/100/5/941.full.pdf+html, accessed April 2016.

[72] Yang, X-C. and C-M Hwa, 2008, Genetic modification of plant architecture and variety improvement in rice, Heredity 101: 396–404, http://www.nature.com/hdy/journal/v101/n5/full/hdy200890a.html#bib35, accessed April 2016.

[73] Gao, L., S. Ge and D. Hong, 2000, A preliminary study on ecological differentiation with in the common wild rice *Oryza rufipogon* Griff., Acta Agronomica Sinica 26: 210–216, http://caod.oriprobe.com/articles/2590891/A_Preliminary_Study_on_Ecological_Differentiation_within_the_Common_Wi.htm, accessed April 2016.

In summary, it appears most of the research on rice varieties, including research on inbred and hybrid rice varieties, focuses on yield, resistance to localized perils, and quality of the grains produced. The tillering potential of rice and the capacity of varieties to respond to environmental conditions with production of tillers are so highly variable that no tiller factor or factors that could be used for loss adjustment can be derived from the academic literature focused on tillering, tillering genetics, or tillering physiology. Yu and his coworkers note: “Tillering is regulated more by cultural practices and environment than by genetics.”[74] Yet the differences between inbred and hybrid rice, or for that matter between different varieties of inbred rice, are fundamentally genetic. Consequently, the question of whether hybrid rice should have a different tiller factor than inbred rice is moot, while the primary impacts of cultural practices and environment are best captured in an insured’s actual production history rather than in some abstract factor or factors.

[74] Yu B, Lin Z, Li H, Li X, Li J, Wang Y et al. (2007). Tac1, a major quantitative trait locus controlling tiller angle in rice. The Plant Journal 52: 891–898.

VII. DISCUSSION AND CONCLUSIONS

This section of the report provides a summary of the conclusions the Contractor reached concerning the objective of the research described in the TO in the SOW[75] which states: "determine the appropriate tillering factor(s) for conventional and hybrid rice varieties, which are used while performing rice appraisals." This objective can be restated as a research question: "What are the appropriate tiller factors to use while performing rice appraisals for conventional and hybrid rice varieties?" The Contractor's conclusions regarding this research question include:

- Since yield in rice is a function of so many genetic and environmental factors, academic and commercial yield studies focus on relative yields for individual varieties and not on specific yield components such as tiller numbers.
- The timing of a loss of rice plants prior to tillering has a major impact on the number of tillers that can be produced.
- Consequently, almost all available information on tiller numbers is subjective rather than quantitative and focuses on tillering in fields that have not experienced a loss event (i.e., the stand is normal).
- There is a great disparity in the subjective opinions experts express concerning tillering potential of commercial rice in general (Appendix B).
- Moreover, rice yields are influenced substantially by management practices, but only in part because tiller numbers are affected by management practices.
- The Contractor identified no published data that could be used to establish appropriate new tiller factors for rice crop insurance appraisals for inbred and hybrid rice varieties for "tillering incomplete" appraisals.
- Private data to establish appropriate new tiller factors for rice crop insurance appraisals either do not exist or if they exist they are considered proprietary and will not be shared for maintenance of the rice crop insurance products.

As a result of the above-mentioned conclusions, the Contractor believes there is no objective support for the statement in the contract that differences in recommended planting densities are "due to the practice of hybrid rice profuse tillering."[76] To limit appraisals for rice loss adjustment using tiller factors, it may be appropriate to add language in section 6A of the Rice LASH that might state:

> "WHENEVER POSSIBLE, delay any appraisal when damage occurs before heading is complete if it is not clear how tillering and heading will contribute to the appraised yield. If the insured wishes to replant, abandon the field, or put a field to other uses, it may be beneficial to require that representative samples of the field be maintained for final entries on the Production Worksheet."

Since so many factors affect the impact of tillering on yield, the Contractor concludes field trials to establish tiller factors for hybrid varieties would be very difficult to conduct, of limited potential utility, and extremely costly. Due to substantial tillering differences between varieties and not just between inbred and hybrid groups, field trials would need to address the commercial

[75] USDA, RMA, 2016. Solicitation for Rice Loss BPA and Order 1 (D16PS00016), Loss Adjustment Policy & Procedure Support for the Rice BPA for Order Number D16PB00137, Tillering Factors for Hybrid Rice, page 2 of 5.
[76] *Ibid*.

varieties being planted and a variety of planting densities for all those varieties. Introduction of new varieties would require an ongoing effort to expand and update the tiller factor table (and perhaps the tiller to pound yield factors) for different varieties (and perhaps types), locales, and loss dates at the least. There would need to be data collection to address different timings of the loss events, different causes of loss, different soil types, and differences in seeding practices. Long-term yield data series would need to be collected to compare yields in loss units and in units not unaffected by a loss. Careful supervision of post-loss management practices would be required. In summary, the permutations and combinations of the conditions that would need to be evaluated would exceed the capacity for typical field trials. There is no evidence these costly and time-consuming efforts would produce appropriate tiller factor values for loss adjustment of all rice production, production of inbred and hybrid rice, or even for production of a single rice variety.

Furthermore, for all the same reasons, and because of the burden it would impose on AIPs and RMA, the Contractor concludes collecting the necessary data through changes in the data requirements for PASS could not be justified since the likelihood of collecting adequate measures of all the variables needed to develop statistically significant tiller factors for subsets of insured rice is extremely small.

VIII. RECOMMENDATIONS

This section of the report provides the Contractor's recommendation regarding the existing tiller factor used in adjustment for losses of insured rice that occur prior to the completion of tillering. The SOW provides the following guidance regarding these recommendations:

> *Any recommendations or improvements the contractor identifies must adhere to sound statistical procedures and standard actuarial principles that provides meaningful risk management benefits to the insured(s) and to the Government. The contractor should clearly state and support all assumptions, findings, and determinations in sufficient detail to enable independent researchers or RMA personnel to reproduce the analysis for validation. Recommendations need to be cost effective and able to be administered from the perspective of the insured and the Approved insurance Providers (AIPs).*[77]

"Actuarial science is concerned with the development of models which approximate the behaviour of reality and have a degree of predictive power… Sound statistical procedures [require that quantitative recommendations be based on reliable data. In the absence of such data, actuarial science may accommodate] low-level generalisations, recognising the limited nature of available regularities. [However,] knowledge of the variations in the specific locality of interest" is essential to an appropriate actuarial analysis. [78]

The Contractor has concluded data limitations and the numerous variations in tillering resulting from location, soil type, and management practices, and other factors render any attempt to provide different tiller factors will introduce substantial burdens on the AIPs and RMA without providing more accuracy and precision in estimating the yield that might have been obtained if the crop had been maintained. Therefore the goals of actuarial science as detailed above will not have been met by this effort. Consequently, the Contractor recommends RMA develop an alternative to the tiller factor approach for appraisal of early season losses in rice, including for appraisals focused on replant payments. One such alternative would be to require the insured to maintain the crop until an appraisal can be completed following tillering or perhaps even following heading. This approach would address the impact of plant density on yield, the potentially variations in tillering among different rice varieties, the impact of management practices on tillering, and the fact the timing of a loss event will impact the number of tillers that can be produced. Another alternative would be to develop a direct surviving-plant (stand density) to yield factor that eliminates the intervening calculations used in the current early-season-loss appraisal procedures. There are likely other alternatives that could be used to address loss adjustment for early season losses insured under the FCIC Rice Crop Provisions. A specific recommendation regarding the most appropriate alternative to the existing approach would require substantial added research beyond the scope of this Task Order

According to the solicitation, the insurance industry is concerned the current procedures for adjustment of early season losses of rice might not be appropriately addressing the yield potential of appraised fields because "the tillering factor currently used while performing rice appraisals is

[77] *Ibid*., pages 2 and 3.
[78] Pemberton, J.M., 1999, The Methodology of Actuarial Science, The British Actuarial Journal, 5:115-195. British spellings of terms are quoted as published.

based on conventional rice varieties only,"[79] To address this concern," the Contractor recommends RMA consider, at least in the short run, adding stronger language in section 6A of the Rice LASH that indicates the value and utility of delaying appraisals when tillering is incomplete.

[79] USDA, RMA, 2016. Solicitation for Rice Loss BPA (Loss Adjustment Policy & Procedure Support for the Rice BPA, Statement of Work: Tillering Factors for Hybrid Rice, page 2 of 5.

IX. IMPACT ANALYSIS

This section of the report provides a summary of the impact of the Contractor's recommendation on RMA, the AIPs, and the insureds. If the recommendation regarding adding language in section 6A of the Rice LASH is implemented, that language will need to be drafted and incorporated into the Rice LASH.

Since the recommended changes regarding development of an alternative to the tiller factor procedures for appraisal of early season losses in rice, including for appraisals focused on replant payments, substantially impact loss adjustment, if implemented, AIPs should provide appropriate notice to their adjusters. This notice should be accompanied by a copy of any new Rice LASH (or slipsheets) issued by RMA. Adjusters would likely need to make an additional visit to assess some early season losses. The preliminary visit would document the occurrence of a loss and the cause of loss. The second would be to conduct the appraisal if the crop is maintained through heading. This requirement is not unusual when the extent of a loss cannot easily be established during the initial visit to a field.

Under the proposed changes, AIPs will require some insureds to maintain fields affected by losses prior to the completion of tillering until an appraisal following the completion of tillering can be made. This adds to the burden on the insured. Due to the requirement for irrigation of rice crops, the added burden for the insured may be very great. However, the number of insureds affected by this change in any year is small, especially when compared to the number of units earning premium. Requiring maintenance of fields affected by losses prior to the completion of tillering is not regularly used for other small grains. Early losses to barley, oats, rye, and wheat are all adjusted using a tiller factor.[80] Maintaining representative samples, as opposed to maintenance of entire fields, is required for some insured grain crops grown for seed.[81] Furthermore, maintaining at least appropriate representative samples is recommended for some insured crops which like rice have the ability to recover from damage by developmental strategies that make it difficult to predict yields in the earlier stages of development.[82] Consequently, a recommendation that rice fields be maintained until an appropriate appraisal can be made is not without precedent. However, in contrast, RMA does not offer replant payments for American upland or extra long staple cotton. Therefore, establishing crop provisions for rice which eliminate replant payments would also be supported by precedent.

In conclusion, the proposed development of an alternative to the rice tiller factor procedures for adjustment for early season losses are justified based on the biology of the rice crop:

- Different rice varieties have different and non-quantifiable tillering potential;
- Number of tillers differs based on planting density;
- Number of tillers differs based on soil type;
- Number of tillers differs based on planting procedures;
- Number of tillers is influenced by the health of the surviving plant;

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[80] That such factors are used for other grains does not diminish the importance of the numerous issues that argue against use of a tiller factor in rice loss adjustment.

[81] See for example the Hybrid Seed Loss Adjustment Standards Handbook, pages 17 and 22, which require insureds with losses to sorghum and corn seed to maintained representative samples until an appropriate appraisal can be made.

[82] See for example the Sesame Pilot Loss Adjustment Standards Handbook (FCIC-25015 (11-2014)), page 13, which states: "Whenever possible, require the producer to maintain a portion of the crop so the Harvested Production Method can be used."

- Not all tillers produce productive plants;
- Secondary tillers are less productive than primary and some of the breeding efforts have affected the extent to which tillering beyond primary tillering occurs;
- Yield is influenced substantially by management practices, only in part because tillering is influenced by management practices; and
- The timing of a loss event prior to tillering will impact the number of tillers that can be produced.

The burden imposed by implementation of the proposed changes is modest compared to the benefit from a process that better establishes an appropriate value for the production to count.

Appendix A

Representative Recommended Rice Varieties and Varieties under Investigation in the United States

Table A1. Brief Description of Southern State Conventional, Clearfield and Hybrid Rice Cultivars

Variety/Hybrid	Year Released and State	Highlights
Arize QM1003	2009 – Bayer Cropscience	A mid-season, long-grain hybrid with good grain and milling yield.
Banks	2004 – Arkansas	A short-season, long-grain LaGrue-type rice with blast resistance.
Bengal	1992 – Louisiana	A short-season, semi-dwarf, medium-grain with good yield potential and milling quality. It has a preferred large grain size.
Bowman	2008 – Mississippi	A short-season, long-grain rice with good grain and milling yield and high amylose content.
Caffey	2011 – Louisiana	A semi-dwarf, short-season, medium-grain rice variety with excellent yield potential and milling quality. Caffey is characterized by a very bold uniform milled grain. It is moderately susceptible to sheath blight, blast and sheath blight.
Catahoula	2008 – Louisiana	A short-season, semi-dwarf long-grain with good grain and milling yield and resistance to rice blast.
Cheniere	2003 – Louisiana	A short-season, semi-dwarf long-grain with good yield potential, less oil in bran than Cocodrie, and improved straighthead tolerance.
CL111	2009 – BASF, Horizon Ag	A very short-season, semi-dwarf long-grain similar to Trenasse with high tolerance to Newpath herbicide. It is very susceptible to sheath blight and susceptible to blast and straighthead.
CL131	2004 – BASF, Horizon Ag	A very short-season, semi-dwarf long-grain similar to Cocodrie with high tolerance to Newpath herbicide. It is very susceptible to sheath blight, moderately susceptible to blast and very susceptible to straighthead.
CL142 AR	2009 – BASF, Horizon Ag	A short-season long-grain Clearfield variety similar to Wells with excellent yield potential and good milling potential. It is susceptible to blast and moderately susceptible to sheath blight and straighthead.
CL151	2008 – BASF, Horizon Ag	A short-season, semi-dwarf long-grain Clearfield rice similar to Cypress with high tolerance to Newpath herbicide. It is very susceptible to sheath blight, susceptible to blast and susceptible to straighthead.
CL152	2011 – BASF, Horizon Ag	A short-season, semi-dwarf long-grain Clearfield rice similar to CL151 with high tolerance to Newpath herbicide. It has excellent yield potential and milling quality. CL152 is susceptible to sheath blight and moderately susceptible to both blast and straighthead.
CL161	2002 – BASF, Horizon Ag	A short-season, semi-dwarf long-grain Clearfield rice similar to Cypress with high tolerance to Newpath herbicide. It is very susceptible to sheath blight, moderately susceptible to blast and susceptible to straighthead.
CL162 (MS)	2011 – BASF, Horizon Ag	A short-season long-grain Clearfield rice variety with commercially acceptable tolerance to Newpath and Beyond herbicides. It is a high-yielding variety with very good milling quality and excellent straw strength. CL162 is susceptible to blast, sheath blight and straighthead.

Variety/Hybrid	Year Released and State	Highlights
CL171 AR	2005 – BASF, Horizon Ag	A short-season, semi-dwarf long-grain Clearfield rice similar to Wells with high tolerance to Newpath herbicide. It is moderately susceptible to sheath blight, susceptible to blast and moderately susceptible to straighthead.
CL181 AR	2009 – BASF, Horizon Ag	A short-season, semi-dwarf long-grain Clearfield rice with good yield potential and milling yield potential. It is very susceptible to sheath blight and susceptible to blast.
CL261	2009 – BASF, Horizon Ag	A short-season, semi dwarf medium-grain Clearfield rice with good yield potential and milling quality. It is moderately susceptible to sheath blight and blast and susceptible to straighthead and bacterial panicle blight.
CL XL729	2006 – Rice Tec, Inc.	A short-season long-grain hybrid with excellent yield potential, good milling yield potential, and good disease resistance.
CL XL730	2005 – Rice Tec, Inc.	A short-season long-grain hybrid with excellent yield potential, good milling yield potential, and good disease resistance.
CL XL745	2007 – Rice Tec, Inc.	A short-season long-grain hybrid with excellent yield potential, good milling yield potential and good disease resistance.
CL XL746	2008 – Rice Tec, Inc.	A short-season long-grain hybrid with excellent yield potential, good milling yield potential and good disease resistance.
Cocodrie	1997 – Louisiana	A short-season, semi-dwarf long-grain with good yield potential and milling quality.
Cybonnet	2004 – Arkansas	A short-season, semi-dwarf long-grain with good yield potential and excellent milling quality similar to Cypress. It has blast resistance similar to Katy.
Cypress	1992 – Louisiana	A mid-season, semi-dwarf long-grain with good yield potential and excellent milling quality and excellent seedling vigor.
Drew	1996 – Arkansas	A mid-season long-grain with average yield potential and milling quality. It is blast resistant, straighthead tolerant, and has a larger kernel size than Kaybonnet.
Francis	2002 – Arkansas	A very short-season long-grain with excellent yield potential, susceptible to rice blast.
Jefferson	1999 – Texas	A very short-season, semi-dwarf long-grain variety with good yield potential. It is moderately susceptible to sheath blight and susceptible to blast.
Jupiter	2005 – Louisiana	A mid-season medium-grain with excellent yield potential, good milling quality, and resistance to bacterial panicle blight. It has a smaller seed size than Bengal.
Kaybonnet	1994 – Arkansas	A short-season long-grain with good yield potential and good milling quality. It is resistant to rice blast and has a small grain size.
LaGrue	1993 – Arkansas	A short-season long-grain with excellent yield potential and variable milling quality. It is susceptible to rice blast and kernel smut.
Lemont	1983 – Texas	A mid-season, semi-dwarf long-grain with good yield potential and milling quality. It has poor seedling vigor.
Neptune	2008 – Louisiana	A mid-season medium-grain with excellent yield potential, good milling quality, and partial resistance to bacterial panicle blight. It has a seed size that is similar to Bengal.
Newbonnet	1983 – Arkansas	A mid-season long-grain with good yield potential and good milling quality. It is susceptible to rice blast.
Presidio	2005 – Texas	A short-season, semi-dwarf long-grain with good yield potential and good milling quality.

Variety/Hybrid	Year Released and State	Highlights
Rex	2010 – Mississippi	A short-season, semi-dwarf long-grain with good yield potential, excellent straw strength and very good milling quality. Rex is susceptible to blast and sheath blight and moderately susceptible to straighthead.
Roy J	2010 – Arkansas	A mid-season, standard-statured long-grain with excellent yield potential, very strong straw strength, and good milling yield. Susceptible to blast and moderately susceptible to sheath blight.
Spring	2005 – Arkansas	A very short-season long-grain with good yield potential and rice blast resistance. It is one of the earliest maturing long-grain rice lines.
Saber	2001 – Texas	A mid-season, semi-dwarf long-grain with resistance to some rice blast races. It has yield and quality characteristics similar to Cypress.
Taggart	2009 – Arkansas	A mid-season, standard-statured long-grain with good yield potential and large kernel size.
Templeton	2009 – Arkansas	A mid-season, standard-statured long-grain with good yield potential and resistance to all of the know races of rice blast disease in Arkansas.
Trenasse	2005 – Louisiana	A very short-season long-grain with good yield potential. Very susceptible to sheath blight and straighthead; susceptible to blast.
Wells	1999 – Arkansas	A short-season long-grain with excellent yield potential, average milling quality, kernel size similar to Lemont and susceptible to rice blast.
XL723	2004 – RiceTec	A very short-season long-grain hybrid with good yield potential, average milling quality and resistance to blast and moderately resistant to sheath blight.
XL753	2011 – RiceTec	A short-season long-grain hybrid with excellent yield potential, good milling yield potential, and good disease resistance.

Source: Wilson, C.E. Jr., K. Moldenhauer, R. Cartwright, and J. Hardke, University of Arkansas Division of Agriculture Cooperative Extension Service, 2013, Arkansas Rice Production Handbook: Rice Cultivars and Seed Production, J.T. Hardke, Editor, pages 25-27.

Table A2. Brief Description of Southern State Specialty Cultivars.

Variety/Hybrid	Year Released and State	Highlights
AB647	1996 – Anheuser Busch	Selection from Congui, a Chinese indica rice, that is a long-season medium- grain with high yield potential and atypical cooking qualities. Used for brewing.
Baldo	Italy	A very short-season, large-kerneled medium-grain used for risotto.
Bolivar	2001 – Texas	A very short-season long-grain with the same parboiling and canning properties as Dixiebelle.
Della	1971 – Louisiana	Aromatic, mid-season long-grain with low yield potential and average milling quality that is susceptible to lodging.
Dellmati	1999 – Louisiana	A semi-dwarf, aromatic long-grain which elongates when cooked.
Dellmont	1992 – Texas	Semi-dwarf, aromatic long-grain with good yield potential and milling quality.
Dellrose	1995 – Louisiana	A semi-dwarf, aromatic long-grain with high yield potential and good milling quality. It has grain size similar to Della.
Dixiebelle	1996 – Texas	Short-season long-grain with 'Newrex' quality; specialty rice used for canning and steam tables.
Hidalgo	2005 – Texas	A semi-dwarf long-grain with good yield potential and milling quality. Cooking type similar to Toro. It is susceptible to blast and moderately susceptible to sheath blight.
Jasmine-85	1990 – Texas	Aromatic long-grain with good yield potential and poor milling quality.
Jazzman	2008 – Louisiana	Aromatic long-grain with good yield potential and milling quality.
Jazzman-2	2010 – Louisiana	A semi-dwarf, fragrant long-grain with good yield potential, good milling quality and very strong aroma. Jazzman-2 is susceptible to rice sheath blight, bacterial panicle blight and straighthead but moderately resistant to blast.
JES	2009 – Arkansas/Florida	Aromatic long-grain with good yield potential and milling quality.
Koshihikari	Japan	A premium-quality short-grain with low yield potential and good milling quality. It is the standard for Japanese quality.
Neches	2005 – Texas	A long-grain waxy rice with good yield potential (similar to Lemont) used for flour and starch in processing industry. Moderately resistant to blast and very susceptible to sheath blight.
Pirogue	2002 – Louisiana	A short-season short-grain with good yield potential and good milling quality.
Sabine	2006 – Texas	Short-season long-grain with 'Dixiebelle' quality. Similar agronomic traits as Dixiebelle, with higher yield potential. Specialty rice used for canning and steam tables.
Sierra	2005 – Texas	An aromatic long-grain with the fragrance and cooking qualities of a basmati- style rice.
Toro 2	1984 – Louisiana	Special-purpose, low amylase and low gelatinization temperature, long-grain rice. Toro 2 cooks moist and sticky like a medium-grain rice.

Source: Wilson, C.E. Jr., K. Moldenhauer, R. Cartwright, and J. Hardke, University of Arkansas Division of Agriculture Cooperative Extension Service, 2013, Arkansas Rice Production Handbook: Rice Cultivars and Seed Production, J.T. Hardke, Editor, pages 27.

Table A3. California Rice Classification, Commercial Impact, and Tier Designation

Variety	CI	Non-CI	Tier
Long Grain			
A-201	✓		1
A-301	✓		1
Aromatic Long Grain Red Rice	✓		2
Calmati-201	✓		1
Calmati-202	✓		1
Donana		✓	
L-202 (not in production)		✓	
L-203 (not in production)		✓	
L-204 (not in production)		✓	
L-205 (not in production)		✓	
L-206		✓	
Long Grain Red Rice	✓		2
P-2 Denosa		✓	
P-3 Isla		✓	
A-202	✓		1
Medium Grain			
Black Rice – SWF	✓		2
Calriso	✓		1
Guadiamar		✓	
Hong Kong Black (HKB-102)	✓		2
Kokuho Rose		✓	
KR4		✓	
M-103 (not in seed production)		✓	
M-104		✓	
M-105		✓	
M-201		✓	
M-202		✓	
M-204 (not in seed production)		✓	
M-205		✓	
M-208		✓	
M-209		✓	
M-401		✓	
M-402		✓	
Millrose		✓	
NFD181		✓	
Riz Rouge Camargue	✓		2
Rojito (SunWest)	✓		2
SP-211		✓	
SP-311		✓	
SP-411		✓	
Wehani LWE-218 (Lundberg)	✓		2
85-101-10		✓	
91-130-02		✓	
94-158-01		✓	
95-164-01		✓	
M-206 (formerly 98-Y-242		✓	
Arborio	✓		1
Black Japonica (LBJ-489)	✓		2
Black Rice (SunWest)	✓		2
WRM-3538		✓	
M-207 (formerly 00-Y-805 not in seed production)		✓	

Variety	CI	Non-CI	Tier
02-PY-021		✓	
02-PY-014		✓	
RRI-321		✓	
RRI -226		✓	
98-102		✓	
02-121		✓	
04-116		✓	
LMR-206	✓		2
Carnaroli (all subtypes)	✓		1
FRC #11		✓	
FRC #22		✓	
00-117		✓	
02-120		✓	
07-122		✓	
LBJ-115	✓		2
Short Grain			
A-17	✓		1
A-20	✓		1
Akita Komachi	✓		1
Calhikari-201	✓		1
Calhikari 202	✓		1
Calmochi -101	✓		1
Calmochi -203	✓		1
Calpearl	✓		1
Himenomochi (formerly PI 504474)	✓		1
Hitomebore	✓		1
Koshihikari	✓		1
NFD 108	✓		1
NFD 109	✓		1
S-102		✓	
S-201 (not in seed production)		✓	
S-6		✓	
SP-2	✓		1
04-302		✓	
Sasanishiki	✓		1
Surpass	✓		1
WRS-4431	✓		1
Kogane Mochi	✓		1
Calamylow-201 (formerly BL-1)	✓		1
BL-2 (not in production)	✓		1
Vialone Nano	✓		1
Carnaroli (all subtypes)	✓		1

Source: California Rice News, 2016, Varieties Currently Reviewed, http://www.calricenews.org/wp-content/uploads/2016/01/Varieties-currently-reviewed.doc, accessed April 2016.

Commercial Impact

- Commercial Impact Tier 1 – commingling with Calrose will reduce value or increase handling or sorting costs. Standard industry practices can mitigate.
- Commercial Impact Tier 2 – commingling with Calrose will reduce value or increase handling or sorting costs. Standard industry practices and additional planting restrictions and handling practices can mitigate.

Appendix B

Frequency of Rice Tillering as Documented in Representative Academic Literature

Table B1. Frequency of Rice Tillering as Documented in Representative Academic Literature

Tillers per Plant	Authors	Year	Primary Source	Notes
1.5-4	M.A.Badshah and T. Naimei[83]	2014	no	Extrapolated values
2-5	D.H. Beighley[84]		no	Productive tillers only
3-4	Chen *et al*.[85]	2007	no	
2-4	D. Dickey *et.al*.[86]	2015	no	At normal planting densities
4-5	R. Dunand and J. Saichuk[87]	2014	no	Primary Tillers
1-3	L. Espino.[88]	2014	no	
1.8-4.8	N.K.Fageria[89]	2007	no	Productive tillers only
15-48	S. Ishikawa[90]	2005	no	Tillering potential
2-30	K. Moldenhauer *et al.*[91]	2014	no	
2-10	S. Peng et al.[92]	1993	no	Productive tillers only
2.6-9.6 1.7-9.5	} A.L. Ranawake *et al*.[93]	2013	yes	All tillers Productive tillers only
4-50	S. Yoshida and Y. Hayakawa[94]	1970	yes	Grown in laboratory
1.5-8	L. Zou *et al*.[95]	2004	yes	

83 Badshah, M.A., T. Naimei,, Y. Zou, M. Ibrahim, and K. Wang, 2014, Yield and tillering response of super hybrid rice Liangyoupeijiu to tillage and establishment methods, The Crop Journal, 2:79-86.

84 Beighley, D.H., 2010, Growth and Production of Rice, Soils, Encyclopedia of Life Support Systems: Plant Growth and Crop Production - Volume II, W.H. Verheye, editor, page 35ff.

85 Chen, L-y., Xiao Y-h., Tang W-b., and Lei D-y., 2007, Practices and Prospects of Super Hybrid Rice Breeding, Rice Science, 14:71-77.

86 Dickey, D., L. Espino, M. Leinfelder-Miles, C. Mutters, K. Al-Khatib, L. Godfrey, J. Hill, B. Linquist, K. Tumber, and K. McKenzie, 2015, Variety Selection and Management, California Rice Production Workshop, v15, University of California Rice Production Manual, 3.1-3.26.

87 Dunand, R., and J. Saichuk, 2014, Rice Growth and Development, Louisiana Rice Production Handbook, pp 41-53

88 Espino, L., 2014, Rice Yield Components, UC Rice Blog: California Rice Production,

89 Fageria, N.K., 2007, Yield Physiology of Rice, Journal of Plant Nutrition 30:843-879.

90 Ishikawa, S. M. Maekawa, T. Arite, K. Onishi, I. Takamure and J. Kyozuka, 2005, Suppression of Tiller Bud Activity in Tillering Dwarf Mutants of Rice, Plant Cell Physiology, 46:79-86.

91 Moldenhauer, K., C.E. Wilson, Jr., P. Counce, and J.T Hardke, 2014, Rice Growth and Development, Arkansas Rice Production Handbook, pp. 9-20.

92 Peng, S., G.S. Khush and K.G. Cassman, 1993, Evolution of the new plant ideotype for increased yield potential, Breaking the yield barrier: Proceedings of a workshop on rice yield potential in favorable environments, IRRI, 29 November 4 December 1993. International Rice Research Institute, P.O. Box 933, Manila 1099, Philippines, pages 5-20.

93 Ranawake, A.L., U.G.S. Amarasingha, and N. Dahanayake, 2013, Agronomic characters of some traditional rice (*Oryza sativa* L.) cultivars in Sri Lanka, Journal of the University of Ruhuna, 1:3-9.

94 Yoshida, S., and Y. Hayakawa, 1970, Effects of Mineral Nutrition on Tillering of Rice, Japanese Society of Soil Science and Plant Nutrition, 16:186-191.

95 Zou, L., M.J. Stout and R.T. Dunand, 2004, The effects of feeding by the rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, on the growth and yield components of rice, *Oryza sativa*. Agricultural and Forest Entomology, 47-54.

Attachment I

2014 Rice Loss Adjustment Standards Handbook (Updated Handbook including Slipsheets)

USDA RMA provides both current and historic loss adjustment materials on its Website (http://www.rma.usda.gov/). The 2014 Rice Loss Adjustment Standards Handbook (Updated Handbook including Slipsheets) from http://www.rma.usda.gov/handbooks/25000/2014/14_25410-2h.pdf is incorporated into the report by reference, with agreement of the Government.