

Yields and property variations for rice straw in California

M. D. Summers^a, P. R. Hyde^b, B. M. Jenkins^a

^aDepartment of Biological and Agricultural Engineering,
University of California, One Shields Ave., Davis, CA, USA 95616

^bInternational Agricultural Development Program
Fax: 530-752-2640; mdsummers@ucdavis.edu

Introduction

Biomass utilization systems require accurate data on yields and properties for design purposes. Most information to date on rice straw yields has been provided by monitoring baling operations to measure the tonnage of straw obtained from fields. In previous studies, there has been a large variation in yields, from 2.9 to 9.4 Mg ha⁻¹. Yield variations are difficult to account for, and have been anecdotally attributed to effects of variety, season, location, stubble height, equipment losses, etc. There is a need for baseline straw yield information for variety, location, season, and cutting height in order to understand rice straw harvesting and handling losses. Baseline information is also needed on rice straw properties for machine and process design. Currently, this information is limited and insufficient for engineering uses. The goal of this study is to generate accurate yield and property data for rice straw of common varieties grown in typical California conditions.

Materials and Methods

Six common early varieties of rice (M202, M204, L204, L205, S102, and CM101) and two late varieties (M401 and M402) were tested. The early trials took place at two California sites, one in Colusa Co., the other in Yuba Co.; late trials were held in Sutter Co. and Glenn Co. All trials were located adjacent to the Statewide Variety Trials in a grower's field of an equal maturing variety and were subjected to the grower's management practices. The varieties were planted in a randomized complete block design with four replications. Plots measured 10' x 20'. Plots were harvested with a rice plot harvester fitted with a container attached to the back of the combine. The container was weighed after collecting all the straw and chaff deposited by the combine. Grain was also weighed, and both straw and grain were sampled for moisture content. Whole plant samples were also collected at harvest for compositional and biomass distribution analyses.

Randomly selected plant samples from each plot were measured for length, weighed on an analytical balance, and divided into components: panicle, node, internode and leaf. Component length and weight were recorded and used to determine linear weight of each internode. We created a biomass distribution model using these linear weights. This model enabled us to calculate yields expected at different cutting heights. Each variety was divided into components to determine the botanical fractions of the straw (leaf, stem, node, and panicle). Whole plant samples and each fraction of M202 were air dried and ground. Ground samples were ashed and analyzed for silica (acid-insoluble ash) and cellulose content.

Results

Straw Yields: Field results for straw yield and straw to grain ratios are shown in figures 1 and 2. Biomass (straw) yields ranged from 3.34 dry tons acre⁻¹ (Glenn Co.) to 5.18 tons acre⁻¹ (Yuba Co.). On average, straw yields from Yuba and Sutter counties were higher than those from the Colusa and Glenn County sites. Straw to grain ratios were also highest in Yuba and Sutter counties for the 1999 growing season. In addition, individual plant weights were greatest in these counties, contributing to higher yields. Although these results come from only one season of data, they do indicate that site and variety have an impact on straw yields and straw to grain ratios. Farmers in different counties may expect straw yields to differ as well. This study is ongoing for the early varieties in Colusa and Yuba counties.

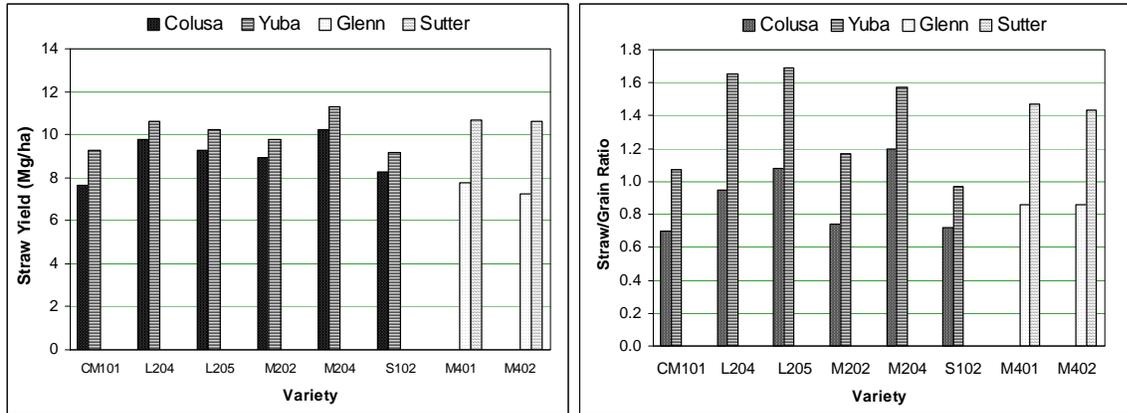


Figure 1: Straw yields and straw to grain ratios from rice straw variety trials.

Straw yields also vary greatly due to cutting height. Figure 2 shows the percentage straw yield at different cutting heights. This is based on linear weight data collected for early and late varieties. As expected, cutting closer to the ground yields greater straw offtake. For example, cutting at four inches could yield 4 tons acre⁻¹, while at 12 inch cutting height yields drop to less than 3 tons acre⁻¹. This is due in part to a nonlinear biomass distribution, with more weight concentrated near the base of the rice plant.

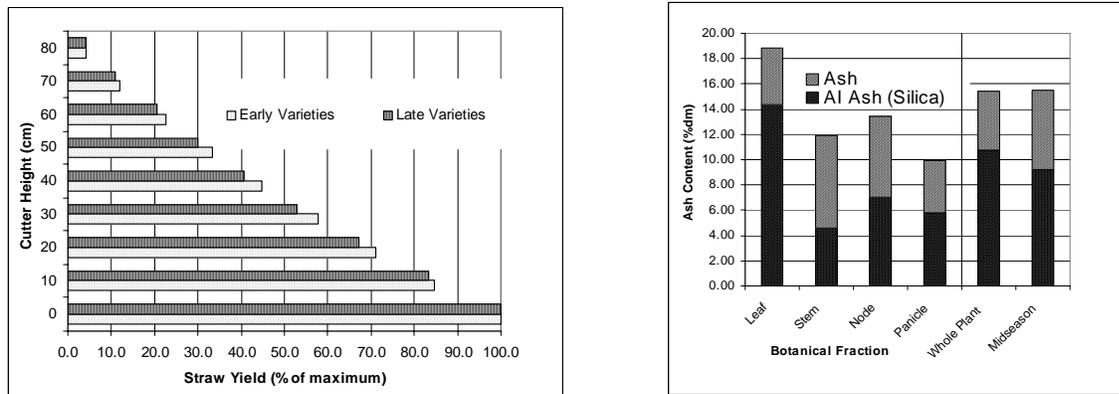


Figure 2: Straw yield as effected by cutter height. Figure 3: Ash and silica content of M202 fractions

Straw Properties: Typical elemental and structural compositions for rice straw are shown in Table 1. Ash, silica, extractive, and cellulose concentrations were not significantly different among the varieties tested. However, we have so far only tested samples from one season, further work is continuing.

Table 1. Typical rice straw properties for California varieties

Elemental Analysis (% by weight, dry)							Structural (% by weight, dry)					
C	H	O	N	S	Cl	K	Cellulose	Hemicell.	Lignin	Ash	Silica	Extr.
41	5	38	0.7	0.08	0.4	1.7	33	28	10	16	12	10

Straw properties, particularly ash and silica content, did vary significantly by botanical fraction. We found that rice straw is over 60% (by weight) leaf (this includes sheath), around 30% stem, 5% node, and 5% panicle. Figure 3 shows ash and acid insoluble ash results for M202, the most common variety grown in California. Acid-insoluble ash gives a relatively good estimate of silica content in rice straw. While silica is less than 5% of the stem fraction, it makes up nearly 15% of leaf dry weight. These results were typical for all varieties. Silica increased with height above the ground, presumably because more leaf tissue makes up a higher percentage of biomass near the top of the plant. Silica concentrations also increase as the plant matures as harvest plants had higher silica contents than those collected at midseason (figure 3). Silica and ash are typically undesirable properties in rice straw and there may be ways to take advantage of variations by variety, location, fraction and maturity. This also applies to other properties.