California Fish and Game 82(4):187-191 1996

PRELIMINARY ESTIMATE OF RICE PRESENT IN STRIP-HARVESTED FIELDS IN THE SACRAMENTO VALLEY, CALIFORNIA

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Rice is critical winter food for the large populations of migratory waterfowl in the Sacramento Valley (Miller 1987, Miller et al. 1989) because remaining wetlands are limited and do not supply all required food resources (Heitmeyer 1989). An average of 388 kg/ha of rice is present in conventionally harvested fields in the Sacramento Valley (Miller et al. 1989). This rice is potentially available for wintering waterfowl and other birds to consume, although 20-25% may not be accessible because of the presence of straw (Clark and Greenwood 1987). An updated assessment of the quantity of rice seed present in harvested fields is needed because a new harvesting technology was introduced to the Sacramento Valley in 1990, potentially changing the amount of rice available to migratory birds. The new method uses a "stripper header" attached to the combine harvester as a replacement for the conventional cutter-bar header (Bennett et al. 1993). This relatively inexpensive (about US$30,000) innovation allows faster harvest (3.2 - 12.8 km/h) than with conventional headers (1.6 km/h).

The conventional cutter-bar header cuts the plant stems, creating stubble, and pulls the seedheads and cut straw into the machine. Threshing components separate and retain the seeds and the straw is carried out the back to fall on the ground. Loose seeds and seeds still attached to incompletely processed seedheads become waste rice. Additional waste rice results from shatter as the machine passes through the field and impacts adjacent rice plants.

In contrast, the stripper header consists of a rotor with hundreds of stripping teeth attached. The rotor revolves at about 500 rpm, strips the seeds from the seedheads, and sweeps them into the harvester for storage. Thus, the machine does not process cut straw. Some seeds are lost out the back of the machine and shatter still occurs, but few seeds are retained by seedheads after stripping and the potential for wasted grain is reduced. Use of stripper headers will likely increase over time, because they allow faster harvest. This note provides estimates of their efficiency to better predict potential riceland food supplies for wintering waterfowl.

In fall 1985, the U.S. Fish and Wildlife Service sampled 111 conventionally cut rice fields at a rate of two plots per field (Miller et al. 1989). In 1986, investigators sampled 15 fields using eight plots per field. In fall 1993, we repeated methodology from 1986 and sampled eight plots in each of 17 stripped fields. The use of strippers was limited in 1993. Therefore, rather than use a strictly random selection process to obtain sample fields, which would have been inefficient, we located a sufficient number of growers who were going to use strippers in 1993 by consulting a list supplied by University of California farm advisors and from our own phone query of growers that participated in the 1985-86 studies (Miller et al. 1989). From the growers known to be using strippers, we obtained the location and total number of fields that would be stripped. From these, we randomly selected sample fields in Butte (n = 3), Colusa (n = 4), Glenn (n = 2), Sutter (n = 3), Yuba (n = 3), Yolo (n = 1), and Sacramento (n = 1) counties, a similar county distribution as in 1986 (Miller et al. 1989). All stripper headers were of identical make (Shelbourne-Reynolds Engineering, Suffolk, England), but they were mounted on a variety of combine harvesters. Each of the 17 sampled fields was harvested with a different stripper header by a different harvester operator.

In 1993, we repeated field sampling procedures used in 1985-86 (Miller et al. 1989). We used 0.3 m x 5.5 m plots randomly located within fields perpendicular to direction of harvester travel. We collected samples with wet/dry vacuums powered by portable generators and then threshed, cleaned, hand separated, dried, and weighed (dry weight) the seeds.

We used pooled 1985-86 data (Miller et al. 1989) to estimate overall average weight of rice present (kg/ha) in the Sacramento Valley. However, we used only 1986 data to compare with 1993 field averages, because the two plots sampled in each field in 1985 would not produce reliable estimates by field. In 1985, Miller et al. (1989) obtained estimates of rice remaining on the ground and in the cut straw (laying on the stubble) in each of 22 plots (11 fields). We multiplied this resulting percentage by the pooled estimate for total rice present in 1985-86 to obtain estimates of weight of rice in the straw and on the ground. In 1993, we obtained separate straw (rice retained on seedheads after stripping) and ground estimates for all plots.

Budget constraints in 1993 precluded sampling conventionally harvested fields as controls. Instead, we compared 1993 strip-harvest results with pooled 1985-86 data (Miller et al. 1989). In addition, the U.S. Department of Agriculture (USDA) obtained additional estimates from 1985 to 1989 (USDA[1] 1985), and those obtained in 1985-86 were very similar or identical to the results of Miller et al. (1989) for those years. Thus, we concluded that the USDA data reliably measuredconventional-harvest loss through 1989, when the program was terminated. In addition, contacts with agricultural interests and rice growers convinced us that no important changes to conventional harvest had been made since 1989 that would have measurably altered harvest loss. Thus, we elected to use 1985-89 values to broadly represent rice in conventionally harvested fields for comparison with stripper results in 1993, but cautious interpretation of results is advised. We used *t*-tests to compare strip- and conventional-harvest results and chi-square analyses to compare sample distributions in stripped and conventionally harvested plots and fields.

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[1] U.S. Department of Agriculture (USDA). 1985. Enumerator's Manual, 1985 Rice Objective Yield Survey. Crop Reporting Board, Statistical Reporting Service, USDA, Washington, D.C.

The mean amount of rice left after strip harvest in 1993 (344 kg/ha) was not statistically different ($t = 1.42$, $df = 475$, $P > 0.05$) from the pooled mean of388 kg/ha for conventionally harvested fields in 1985-86 (Table 1). The point estimate of rice available to waterfowl in strip-harvested fields in 1993 was less than all USDA estimates for conventional harvest through 1989 (375, 395, 368, 627, and 468 kg/ha for 1985 through 1989) (G.K.H. Chong, California Agricultural Statistics Service, Sacramento, California, pers. comm.). Rice available in conventionally harvested fields may have been higher still in 1993 because harvest losses correlate positively with yield (Miller et al. 1989) and average yield was 9,320 kg/ha in 1993 compared to 7,885-8,750 kg/ha from 1985 to 1989 (California Agricultural Statistics Service, Sacramento, California).

An average of about 290 kg/ha of rice was left on the ground with both harvest techniques (Table 1). However, strip harvest left significantly less seed in the straw (52 kg/ha or 15% of total) than did conventional harvest (97 kg/ha or 25% of total) ($t = 2.18$, $df = 155$, $P < 0.05$) (Table 1). Thus, strip harvest in 1993 left about45 kg/ha less rice in fields than did conventional harvest in 1985-86.

The majority of sample plots contained an equivalent of ≤ 500 kg/ha of rice with both harvest techniques (Fig. 1); however, rice was more uniformly distributed in conventionally cut fields than in strip-harvested fields ($\chi^2 = 19.56$, $df = 8$, $P < 0.05$). For example, in conventional fields, only 36% of individual sample plots had ≤ 250 kg/ha of rice, but in stripped fields, 51% of plots contained ≤ 250 kg/ha (Fig. 1). Similarly, when comparing field means (Fig. 2), only 27% of conventional fields averaged ≤ 250 kg/ha compared with 42% of stripped fields; however, the frequency distributions were not significantly different ($\chi^2 = 1.17$, $df = 6$, $P > 0.05$), possibly because the number of fields sampled was small.

In 1993, harvester operators were still learning the most efficient way to use strip-harvest technology. We saw evidence of poor stripper control in many fields, such as excessive amounts of rice on the ground in some areas and unharvested patches in other areas of the same fields (see Fig. 1). Much of this variability probably

Table 1. Mean weight (and standard error) of rice (kg/ha) in conventionally harvested (1985-86 pooled; Miller et al. 1989) and strip-harvested (1993) rice fields in the Sacramento Valley, California.

	Ground	Straw	Percent in straw[a]	Total	No. of Plots
Conventional	291(37)[b]	97 (17)[b]	25	388(20)	341
Stripped	292(37)	52 (6)	15	344(28)	136

[a] Percentage of rice in straw for conventional harvest was obtained in 1985 using straw/ground comparisons in 22 plots (see text), and this percentage was applied to Total to derive the Ground and Straw results shown for conventional harvest. Straw data for Stripped were obtained in all plots in 1993.

[b] S.E.s for Ground and Straw for conventional harvest are S.E.s from the straw/ground data obtained from 22 plots in 1985 (see text) because estimates could not be obtained for pooled 1985-86 data except for Total.

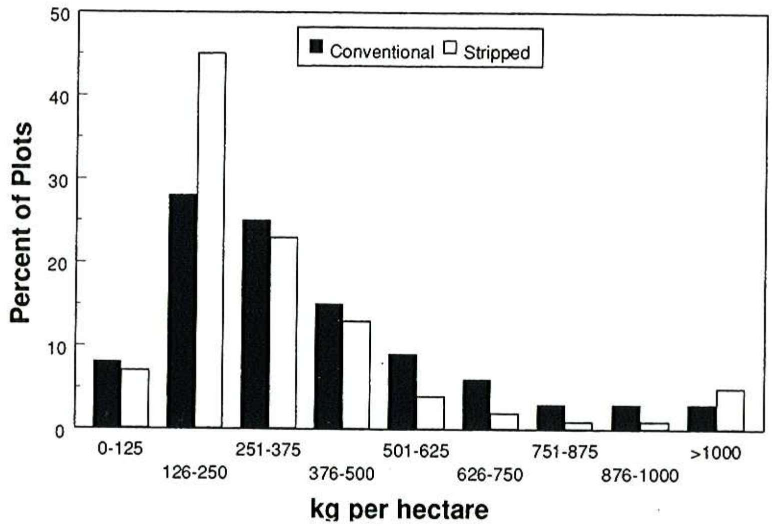

Figure 1. Proportionate distribution of rice remaining after harvest among sample plots in conventionally harvested (1985-86 pooled; Miller et al. 1989) and strip-harvested (1993) rice fields in the Sacramento Valley, California.

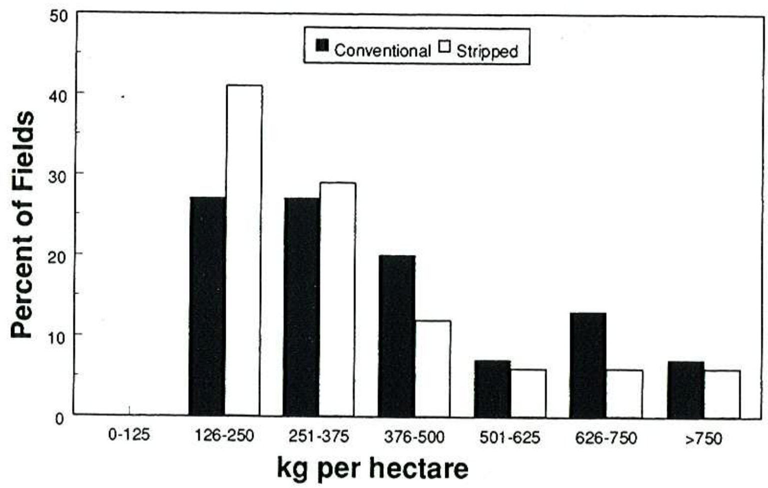

Figure 2. Proportionate distribution of rice remaining after harvest among fields in conventionally harvested (1986; Miller et al. 1989) and strip-harvested (1993) rice fields in the Sacramento Valley, California.

resulted from excessive harvester speed (Bennett et al. 1993). As practical knowledge of stripper use improves, harvest efficiency may increase. Given the speed and low cost of strippers, we expect their use to expand markedly and our results should be verified with additional investigation when the operational use of this technology matures in the years ahead.

Our results show that the total amount of rice present in stripped fields in 1993 was not markedly different from that in conventionally harvested fields in previous years and the difference we found resulted solely from the reduced amount of seed retained in the straw. Given the large quantity of rice remaining in strip-harvested fields, food supply for wintering waterfowl may still be adequate. However, the relative foraging efficiency of waterfowl in strip-harvested and conventionally cut fields is not known, although the tall (usually >1 m) straw left standing after stripping has been shown to deter use by foraging geese (J. Day, U.S. Geological Survey, Biological Resources Division, Dixon, California, unpubl. data). Mowing may be needed to accommodate foraging waterfowl. Also, the probability of waterfowl locating productive foraging areas will be reduced in regions dominated by stripper harvest because the distribution of seed in stripped fields is less uniform than in conventionally harvested fields.

Our results have implications for waste rice availability to waterfowl in Arkansas, Texas, Louisiana, and other rice growing regions in waterfowl wintering range, because stripper use is increasing there as well. Also, stripper headers are used to harvest wheat and barley and this technology is now being widely used in the Klamath Basin. Efficiency of stripper technology needs to be assessed for other regions and crops to determine if waterfowl foraging opportunities may be impacted.

ACKNOWLEDGMENTS

We thank the 17 Sacramento Valley rice growers who granted us permission to collect samples on their land. University of California Farm Advisors S. Scardaci and J. Williams provided names of growers who would be using stripper headers in 1993. J. Day, M. Casazza, J. Fries, and D. Storm assisted in collecting and processing rice samples.

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Received: 5 September 1995
Accepted: 13 October 1996