1971-72 Report
COMPREHENSIVE RESEARCH ON RICE
December 27, 1972

PROJECT NUMBER AND TITLE: RM-11. Machinery and Costs for Soil Incorporation of Rice Straw and Stubble.

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PERSONNEL: Same as above.

OBJECTIVES

To continue investigations of the most promising systems for incorporating rice straw and stubble, expanding the studies to include following through all operations to planting time and to provide information for comparative cost estimates.

WORK IN PROGRESS

Studies similar to those described in the following section are being continued during the 1972-73 fall-spring season in Sacramento and Colusa counties to obtain information under wetter conditions than encountered in 1971-72.

EXPERIMENTS COMPLETED

During 1971-72, several incorporation systems were compared with burning plus conventional tillage in regard to types and numbers of operations required from harvest through seedbed preparation the next spring. Performance rates and fuel requirements were determined. Total costs per acre were calculated for specific operations and for various combinations of operations. Cooperative tests with two growers were conducted on a total of about 75 acres. One experiment was on the Bolen farm in Sacramento County, on Freeport clay loam. The other was on the Poundstone farm in Colusa County, on Sacramento clay loam. We have had no opportunity to work in Butte County.

Fall treatments were (a) burned and disked once, (b) chopped and disked once, (c) chopped and rotary tilled, (d) straw spread by combine (not chopped) and rotary tilled, and (e) chopped with no fall tillage. Spring treatments superimposed on the fall treatments included disking only (once or twice), plowing followed by disking, and rotary tilling portions of the fall rotary-tilled and fall no-tillage treatments. The various combinations of operations are indicated in Table 1.

Disking and plowing were done at 3 1/2 to 4 mph with a 12-ft or 14-ft stubble disk, an 18-ft or 20-ft regular offset disk, or a four-bottom 16-in. moldboard plow. Rotary tilling in the Sacramento experiment was done at 4 mph with a 130-in. Howard Rotavator on a Versatile model 145 four-wheel-drive tractor (180 PTO horsepower). An 80-in. Rotavator on a Ford 8000 tractor (105 PTO horsepower) was used on the Colusa farm. The calculated bite length for the rotary tillage (forward travel per cut) was 10 1/2 to 11 1/2 in., except that part of the Colusa fall treatment was done with a bite length of only 7.7 in.

All chopping was done at 3.5 to 4.9 mph with the same Allis-Chalmers model 782 field forage chopper that was used in 1970, but with gathering wheels added to widen the pickup. A special deflector spreads the chopped straw back onto the field. The theoretical length of cut was 1 1/2 in., which gives actual lengths mostly 1 1/2 to 4 in. The cutterhead on this machine can handle straw at any moisture content likely to be encountered, but straw that was moist from dew or rain caused clogging problems in the pick-up unit.

Results from the various treatments are described in Table 1. Because 1971-72 was an exceptionally dry year, both fall and spring tillage conditions were about as good as one can expect in these soils. Fall-disked treatments required only one or two spring diskings, either without plowing or following plowing. Rotary tilling once in the fall and once in the spring (treatment 3, Table 1) did an excellent job. Pulverization was adequate but not excessive with a bite length of 10 1/2 to 11 1/2 in. Clod size was more uniform than from disking. Decreasing the bite length to 7.7 in. increased energy requirements per acre by about 35% but resulted in no advantage in regard to the effects produced.

In tall stubble, chopping and fall rotary tilling, followed by spring plowing (treatment 12), gave more complete trash coverage than any other treatment--a pertinent factor where complete coverage is important for disease control or other reasons. Otherwise, there appears to be no advantage of fall rotary tilling instead of disking if the field is to be plowed in the spring, unless the field is too wet to disk. Rotary tilling when a fairly heavy yield of long straw was spread but not chopped was not entirely satisfactory.

With the straw chopped in the fall but with no fall tillage (treatments 7, 8, and 14), there was no increase in the total number of tillage operations required. The chopped straw did not interfere with spring plowing (treatment 14), but disking several days before plowing probably would have improved soil pulverization and the coverage of tall stubble.

Energy requirements for specific operations, expressed as engine horsepower-hours per acre, are included in Table 2. These values include energy losses in transmitting power from the engine to the drawbar, as well as the energy required by the implement. They are based on the observed fuel consumption rate in the field and on performance data from the Nebraska Tractor Tests for that particular model and year. Fuel consumption per horsepower-hour was assumed to be 15% greater in the field than in the Nebraska tests.

Estimated costs per acre for the various incorporation systems, not including operations common to all of the combinations on one farm, are listed in Table 1. Assumed operating conditions, and details of the cost calculations for specific operations, are presented in Table 2. The amounts of annual use, especially for the tractors, materially affect the total cost per acre. The assumed values are thought to be typical for many rice farms. For other amounts of annual use, the tractor or implement fixed costs shown in the table can be adjusted in inverse proportion. In a field having a predominance of narrow, irregular-shaped checks, field efficiences and performance rates might be somewhat lower than shown in Table 1, thereby increasing

costs per acre. The 90-horsepower size of track-type tractor assumed for disking and plowing is within the size range of many tractors currently being used by rice growers.

Although rotary tillage requires about 50% more engine output energy per acre than stubble disking to the same depth, the total costs per acre shown in Table 2 for the two operations are about the same. The principal reason for rotary tillage not costing more than stubble disking is that the tractor for the rotary tiller costs $135 per engine horsepower whereas the current price of new track-type tractors is over $300 per engine horsepower. The cost for plowing 8 to 10 in. deep is shown in Table 2 as $6.86 per acre, as compared with $5.43 for stubble disking and $5.34 for rotary tilling. These cost comparisons between rotary tillage and disking or plowing are valid only if the grower already has both types of equipment or needs to buy new equipment of one type or the other.

Under the conditions encountered in the 1971-72 tests, rotary tilling once in the fall and once in the spring (treatment 3) costs about $2.30 per acre more than stubble disking once in the fall plus one regular disking in the spring. Under wetter conditions, however, additional diskings might be needed, thereby increasing the disking costs and perhaps favoring rotary tillage. Plowing and disking (treatment 10) is the most expensive system but usually provides deeper tillage and better trash coverage than disking alone or rotary tillage.

Experience to date indicates that the only extra cost for incorporating rather than burning is the cost of chopping, which usually will be between $2.00 and $3.50 per acre, varying inversely with the amount of annual use for the chopper and the tractor. The saving from eliminating the burning operation is negligible--perhaps 10¢ per acre.

WORK PLANNED

Completion of work in progress for the 1972-73 season.

MAJOR ACCOMPLISHMENTS

It has been demonstrated that, at least under the conditions encountered in the 1971-72 tests, satisfactory incorporation can be accomplished with no extra tillage operations required between harvesting and planting, provided the straw is chopped into short lengths (e.g., 1 1/2 to 4 in.) and spread over the field. A shear-bar-type chopper has been found to be much more effective for size reduction than are impact-type shredders.

Comparative costs for several incorporation systems, based on 1971-72 results, have been estimated.

IMMEDIATELY APPLICABLE RESEARCH RESULTS

If residue incorporation becomes necessary or desirable in the near future, the results from this project provide guidelines for rice growers in the selection of an appropriate incorporation system.

It should be noted that the results reported under this project cover only the "mechanics" and costs of getting the straw and stubble worked into the soil. The results of other tests being conducted to determine the effects of incorporation on yield, disease problems, pests, soil structure, etc., must also be considered in any overall evaluation of the feasibility of incorporation.

EVALUATION OF PROJECT

The imminent prospect of increased restrictions on open-field burning makes it imperative to have alternate methods available for managing rice-straw and stubble residues. Incorporation of straw chopped into short lengths was easy to achieve under the good tillage conditions encountered in the 1971-72 tests. The tests are being repeated in 1972-73 to evaluate the various incorporation systems under more adverse conditions. Tests also need to be conducted in Butte County. Rice growers in this area have indicated that their tillage conditions are more difficult than in other rice areas.

PUBLICATIONS OR REPORTS

Kepner, R. A., and T. H. Burkhardt. Methods and costs for incorporating rice straw. Presented at 14th Meeting of Rice Technical Working Group, Davis, California, June 20-22, 1972.

Kepner, R. A., and T. H. Burkhardt. Machinery and costs for soil incorporation of rice straw and stubble. Multilith report, July 21, 1972. Distributed at Rice Field Day, Davis, California, August 11, 1972.

Table 1. SUMMARY OF TREATMENTS, COSTS, AND RESULTS

Treatment No.	Oper.*	Cost per acre	Remarks
Sacramento County experiment (operations done October 16 and 18 and March 27-28)			
1	BD-d	$ 8.49**	
2	CD-Dd	16.47	Final condition*** comparable with No. 1. Probably could have omitted spring stubble disking (first spring operation), reducing cost to $11.04 per acre.
3	CR-R	13.33	Not much trash showing after rotary tilling; good pulverization. Final condition excellent.
4	CR-d	10.95	Almost as good as No. 3, but a little more trash showing after first spring tillage.
5	SR-R	10.68	Some straw left on the surface in light "windrows" after fall rotary tilling. Clumps on straw were left on the surface after spring rotary tilling or disking (much worse after disking); spot burning required. Considerable trash still showing just before flooding.
6	SR-d	8.30	
7	CN-R	7.99	After rotary tilling, more trash showing than in other chopped treatments but pulverization good. Final condition about as good as other treatments.
8	CN-Dd	11.04	After two diskings, was a little more cloddy than No. 1. Final condition about as good as No. 1.
	All above treatments were subsequently disked after a rain, then landplaned, and finally chisel cultivated in applying aqua ammonia. Costs shown do not include these operations.		
Colusa County experiment (operations done October 23 and 25 and March 15-16)			
9	BD-Pd	15.35**	
10	CD-Pd	17.90	Final condition comparable with No. 9, except slightly more trash showing.
11	CD-Pdd	20.86	Second spring disking was not needed.
12	CR-Pdd	20.77	Was wetter than No. 9 below fall tillage depth, and more cloddy after one spring disking. Final condition more cloddy than No. 9, but trash coverage better than any other treatment.
13	CR-dd	13.91	Excessive amounts of trash left on the surface, possibly because the stubble had been 10 to 12 in. tall. One spring rotary tilling would have been much better than spring disking.
14	CN-Pdd	15.43	Wettest of all treatments when plowed, and more cloddy than others in final condition. Spring disking several days before plowing might have helped.
	Treatments 9-14 were subsequently floated, disked lightly twice in applying liquid urea and herbicide, and spike-tooth harrowed. Costs shown do not include these operations.		

*B = fall burned, C = fall chopped, S = straw spread but not chopped, N = no fall tillage, D = stubble-disked 4-5 in. deep, d = regular-disked 4 in. deep, P = moldboard plowed 8-10 in. deep, R = rotary tilled 4-5 in. deep. Hyphen separates fall and spring operations.

**Assumed 10¢ per acre for burning.

***Final condition always refers to condition just before flooding.

Table 2. PERFORMANCE RATES AND COSTS FOR SEVERAL FIELD OPERATIONS

	Field forage chopper	Stubble offset disk, 4-5" deep	Regular offset disk, 4" deep	6-16" moldboard plow, 8-10" deep	Rotary tillage, 11" bite, 4-5" deep
Tractor type	Wheel	Track	Track	Track	4WD
Maximum horsepower	85 PTO	90 DB	90 DB	90 DB	180 PTO
New cost (incl. tax), $	11,500	32,500	32,500	32,500	25,000
Annual use, hours*	400	500	500	500	400
Life years*	15	15	15	15	15
Implement rated width, ft	15**	12	18	8	10.83
New cost (incl. tax)	4,500	6,300	4,000	2,400	6,000
Annual use, hours*	200	250	150	150	250
Life, years*	10	10	12	12	8
Speed, mph#	4.0	3.5	4.0	3.5	4.0
Field efficiency, percent#	69	75	75	75	80
Avg. capacity, acres/hr	5.00	3.82	6.55	2.55	4.21
Avg. diesel consumption, gph#	3.5	6.0	6.0	5.1	9.6
Engine energy output, hp-hr/acre#	7-10	16-22	10-12	22-26	27-30
Costs, $ per hour					
Tractor fixed costs	3.41	7.70	7.70	7.70	7.41
Implement fixed costs	3.34	3.74	3.56	2.14	4.10
Tractor repairs and fuel##	1.75	3.63	3.63	3.48	3.65
Implement repairs##	2.25	3.15	2.00	1.68	4.80
Total, incl. labor @ $2.50/hr	13.25	20.72	19.39	17.50	22.46
Total cost, $ per acre	2.65	5.43	2.96	6.86	5.34

*Assumed values. Other assumed cost factors are: straight-line depreciation with resale value = 10% of new cost; annual interest = 7% of average investment (3.85% of new cost); taxes + insurance + housing, per year, = 2% of new cost; diesel fuel cost = 15¢ per gal; oil and filter cost = 15% of fuel cost.

**Average spacing of straw windrows from 16-ft combine.

#Based on 1971-72 field test results in Freeport clay or Sacramento clay under reasonably good tillage conditions.

##Estimates based on factors in Agricultural Engineers Yearbook, 1963 (page 232) and 1972 (page 306), except value for rotary-tiller repairs is entirely an assumption (assumed charge per 100 hr = 8% of new cost).