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Burning vs Incorporation of Rice Crop Residues[1]

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ABSTRACT

The effect of burning and incorporating rice (*Oryza sativa*) straw on grain production and the N economy of the crop was evaluated over a 5-year period in a field planted annually to 'Colusa' rice. An additional variable was vetch (*Vicia benghalensis*) planted in the previous autumn for green manure. The rice crop was fertilized annually at rates of 0, 45, 90, 135 kg/ha N.

The amounts of straw produced ranged from 33 to 85 ql/ha (dry), and the N concentration varied from 0.42 to 0.59%, depending on the N and vetch treatments. Amounts of N incorporated in the straw or presumably volatilized by burning the straw ranged from 13 to 50 kg/ha, and N uptake measured in the grain-plus-straw ranged from 38 to 115 kg/ha, but burning caused no measurable decrease in the uptake of N. Highest yields were obtained from 135 N or 90 N plus vetch. Vetch had a positive effect on yield equivalent to about 45 kg/ha of fertilizer N.

Five-year averages of yields of grain show no measurable difference between burning and incorporation at any level of fertilizer or vetch N.

Additional index words: **Straw management, Vetch green manure, Nitrogen uptake.**

THE disposal of rice (*Oryza sativa*) crop residues has received increasing attention for a number of years from both agricultural and nonagricultural segments of our population. To the agriculturists the residues present a growing management problem as grain yields, enhanced by improved technology, are accompanied by increasing straw yields. The traditional method of disposal in California, burning, is faced with more and more opposition and regulation as air pollutant levels from many sources increase and controls are established at state and local levels.

The experiment described here was initiated to compare incorporation and burning of rice straw where rice was grown every year at various fertility levels resulting from chemical N applications and growing vetch as a green manure.

METHODS

Straw management treatments were begun prior to the 1964 cropping season in a field planted annually to 'Colusa' rice at the Rice Experiment Station, Biggs, Calif., on Stockton clay. Straw from the previous crop was incorporated by plowing or was burned. An added variable was purple vetch (*Vicia benghalensis*) planted in the previous autumn, with a control, in combination with the straw treatments. The rice crop was fertilized annually at rates of 0, 45, 90, 135 kg/ha N as ammonium sulfate drilled in. All treatments were repeated on the same plots for 5 successive years in six replications using a split block design with the N rate treatments crossing over the straw and vetch treatments, resulting in two sets of main plot treatments. A 12.6- × 2.6-m strip was harvested out of each 15.3- × 7.0-m subplot for grain yield. One or two 1.22-m² quadrats were cut per subplot for determination of straw-grain ratio and subsampled for Kjeldahl N analysis of grain and straw. Because of a heavy watergrass infestation in two replications in the 1st year, data were used from only the four relatively clean replications, but in succeeding years watergrass was controlled chemically and all replications were used. Grain yields are corrected to 14% moisture, and all other data are on a dry-weight basis.

RESULTS AND DISCUSSION

The yield of grain averaged over 5 crop years showed no difference between burning and incorporation of the residues at any of the fertilizer N levels in either the presence or absence of vetch green manure (Table 1). There was a highly significant effect of N application up to the maximum applied of 135 kg/ha without vetch. Peak yields at about the same yield level, 62 to 64 ql/ha, were obtained at the 90 kg/ha rate of fertilizer N applied with vetch. The vetch green manure had an effect on yield equivalent to about 45 kg/ha of fertilizer N. It has been shown previously that organic sources of N such as vetch are used very effectively by the flooded rice crop (6, 7), with even as much as 100% recovery being attained (8). However, vetch grown as a winter green manure crop grew poorly in this experiment and supplied only about 25% of the N needs of the crop. There was no

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Table 1. Effect of straw management and N fertility treatments on grain and straw yield and N economy of rice averaged for 5 crop years.

Straw and vetch treatment	0 N	45 N	90 N	135 N	Mean	Significance Straw	Significance Vetch
	Grain yield, ql/ha, 14% moist.						
Returned	30	45	59	63	49	ns	
Burned	30	47	58	64	50		**
Returned + vetch	47	58	62	61	57	ns	
Burned + vetch	50	56	64	61	58		
Mean	39	51	61	62			
	Straw yield, ql/ha, dry						
Returned	33	49	67	74	56	ns	
Burned	34	52	67	76	57		**
Returned + vetch	50	63	76	79	67	ns	
Burned + vetch	52	61	83	85	70		
Mean	42	56	73	79			
	Grain N, %						
Returned	0.94	0.94	1.02	1.12	1.01	ns	
Burned	0.94	0.97	1.02	1.13	1.01		**
Returned + vetch	0.98	1.04	1.12	1.21	1.09	ns	
Burned + vetch	0.99	1.00	1.16	1.24	1.10		
Mean	0.96	0.99	1.08	1.17			
	Straw N, %						
Returned	0.42	0.43	0.48	0.52	0.46	ns	
Burned	0.43	0.43	0.48	0.54	0.47		**
Returned + vetch	0.44	0.46	0.51	0.58	0.50	ns	
Burned + vetch	0.44	0.44	0.53	0.59	0.50		
Mean	0.43	0.44	0.50	0.56			
	Straw N, kg/ha						
Returned	13	21	32	38	26	ns	
Burned	14	22	31	40	27		**
Returned + vetch	21	28	37	45	33	ns	
Burned + vetch	22	26	44	50	35		
Mean	17	24	36	43			
	Grain + straw N, kg/ha						
Returned	38	57	83	98	69	ns	
Burned	39	61	83	102	71		**
Returned + vetch	61	79	97	108	86	ns	
Burned + vetch	65	74	107	115	90		
Mean	51	68	93	106			

interaction between the burning and incorporation treatments with the various N treatments.

The yearly variation in grain yield is shown in Fig. 1. Although in 1966 there appeared to be a yield advantage from burning for six out of the eight comparisons with incorporation, there was no discernible pattern favoring one or the other in the other 4 years. Moreover, there was no detectable accumulative difference between burning and incorporation at the end of the 5 years.

The straw yield averaged over the 5 years followed the pattern of grain yields over treatments closely, except that relatively more straw was produced at the highest fertility levels (Table 1). The grand mean of the straw-grain ratio was 1.37 dry basis.

The grand mean N concentration in the grain was 1.05% and in the straw was 0.48%; both responded to increasing N fertility. The critical level for N immobilization during anaerobic decomposition of straw, 0.54% N (8), was exceeded only at the highest fertility level, 135 kg/ha N plus vetch. There was no difference in N concentration of either grain or straw related to the method of handling the straw.

The amount of N contained in the straw varied from 13 to 50 kg/ha, depending on the fertility level (Table 1). It may be assumed that this N was volatilized during the burning, for the most part. This loss was not reflected in a decreased uptake of N by rice grown on the burned plots even in the 5th year of the experiment, and might be attributed to lack of release of straw N because of the lower-than-critical-level N concentrations in the unburned straw. Uptake of

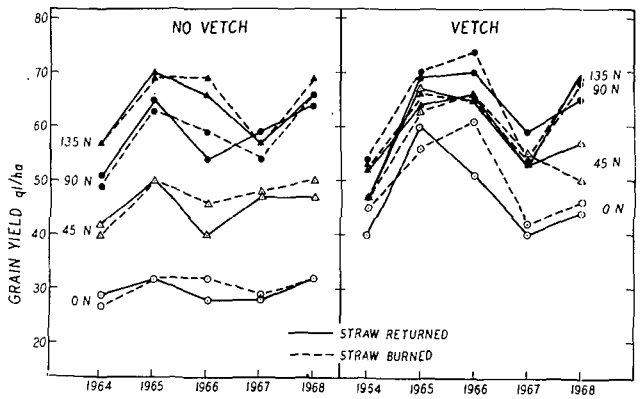

Fig. 1. Effect of straw treatment at several levels of fertility (N in kg/ha) on yield of rice grain.

N by grain and straw ranged from 38 to 115 kg/ha, depending on N fertility level. The apparent efficiency of fertilizer N use averaged about 50% without vetch.

The results of this long-term experiment support the contention that the incorporation of abundant rice crop residues associated with the continuing advance in yields need not be troublesome from the aspect of nitrogen fertility (1, 8).

At some locations various other difficulties have been associated with rice residue incorporation such as disease, e.g., stem rot, *Sclerotia oryzae* (5), insect pests, e.g., stem borers (2), and algae (3) or toxic gas formation (4) with accompanying seedling mortality. In this experiment the Colusa variety, least susceptible of the California varieties to stem rot, was used. Insect problems in California rice-growing areas do not seem to be associated with method of residue management (Grigarick, A.A. Personal communication.) Care was taken to cover the residues well during incorporation, which may have helped to avoid algae and gas problems.

The portion of this experiment without vetch is being continued, and two additional crops show essentially the same results, but these data are being held for reporting when the experiment is terminated.

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