

# Rice straw burning: Alternative policy implications

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Into-the-wind strip lighting, one of two accepted burning methods.

Open field burning of agricultural residues, particularly rice straw, has become a controversial source of visible pollution in the Sacramento Valley Air Basin. Because of the high visibility and potential hazard of the smoke, many residents and public officials are demanding severe curtailment of burning. Rice producers contend that other waste disposal methods are expensive, unreliable during wet weather, and too demanding of labor and equipment during the busy harvest season.

Both local and state policymakers are being pressured to find an efficient and equitable solution to the problem.

## Nature of the problem

From 1968 to 1977 an average of 392,000 acres of rice was harvested annually in California. Approximately 91 percent of the state's 1977 rice acreage was in the Sacramento Valley Air Basin (SVAB) counties of Colusa, Butte, Sutter, Glenn, Yuba, Yolo, and Sacramento. Their production grossed more than \$162 million. The sheer volume of post-harvest residue (ground stubble and cut straw) from so many acres of rice is one of the largest obstacles to the acceptance and implementation of alterna-

tive disposal methods. An average annual California rice crop produces between 1.4 and 2.0 million tons of straw.

The composition of rice straw is also an obstacle. Its fibrous nature and high content of silicon dioxide (SO<sub>2</sub>) cause it to resist decay when incorporated into the soil and can lead to a reduction in yield the following season because of the formation of toxic gases and accompanying seedling mortality. Furthermore, the straw can be physically difficult to incorporate and a greater number of tillage operations may be required to prepare the field for planting. Increased infestations of yield-reducing stem rot disease can also occur with soil incorporation.

Uncertainty and variability of the weather create problems for open-field burning and other disposal schemes. Because rice harvest begins in early September and continues until mid-November, the straw becomes available for disposal when the risk of bad weather is high. Rain and humid weather affect the ease with which straw may be burned, collected and stored, or plowed back into the soil. Since wet straw "burns dirtier," early rains increase particulate pollution from burning

and may limit access to fields with the heavy machinery necessary for plowing under or collecting straw.

It is not surprising, therefore, that post-harvest open-field burning is commonly used. The California Air Resources Board (ARB) reports that in 1976 growers utilized open-field burning on 379,000 acres, or 90.5 percent of the state's total harvested rice acreage. This was equivalent to 45 percent of the total acreage of field crop residues burned in California during that year.

Open-field burning has these advantages: (1) It is effective, reliable, and inexpensive. (2) It places fewer demands on scarce labor and equipment during harvesting. (3) It is reliable under a wide range of weather and field conditions. (4) It is evidently effective in limiting the seasonal carryover and subsequent buildup of stem rot (*Sclerotium oryzae*), a yield-reducing disease prevalent in California rice fields.

Burning of agricultural debris releases into the atmosphere particulates and carbon monoxide, both potentially serious air pollutants in their own right, and hydrocarbons, which may undergo chemical reactions with nitrogen dioxides (in the pres-

ence of sunlight) and produce photochemical oxidants, a common example of which is ozone. These oxidants are primary components of photochemical smog.

Most rice straw burning takes place in autumn when the probability of inversion conditions and the air basin's inability to adequately disperse emissions are at their highest. Of the 1,403,854 tons of agricultural residue burned in the SVAB in 1977, 1,115,886 tons were field crop residues, mostly rice straw. Roughly 66 percent of these residues was burned in October and November. Monthly averages of 38.7 percent of hydrocarbons, 54.7 percent of carbon monoxide, and 47.6 percent of particulate matter present in the air were generated from agricultural burning in the SVAB in October, 1975.

Burning of agricultural residues is regulated by state and local agencies. In accordance with California law, which prevents any regulatory agency from completely prohibiting agricultural burning, the ARB attempts to maintain air quality by allowing open-field burning of agricultural residues only on designated days. These "permissive-burn" days are declared when expected meteorological conditions meet a minimum number of atmospheric criteria regarding existing air quality, different temperatures at different elevations, and daytime wind speed and direction. A valid burn permit, issued by the local Air Pollution Control District (APCD), is required before burning can take place on a permissive-burn day. Agricultural burning is prohibited (on the "no-burn" days) unless a special permit is issued to a producer who can demonstrate that failure to burn would cause "imminent and substantial economic loss."

Pollutants from agricultural burning raise concerns about potential public health hazards. Although the extent to which air pollutants affect human health is not known, it has been shown that particulates in the size range of those produced by agricultural burning can penetrate the pulmonary spaces of human lungs, where they may cause respiratory disorders, including acute bronchitis. Large concentrations of carbon monoxide and photochemical oxidants in the air have been strongly implicated in causing health problems. While further research needs to be conducted, available evidence appears to support concerns about the public health aspects of agricultural burning.

Existing National Ambient Air Quality Standards (NAAQS) have not been strictly observed in the Sacramento Valley Air Basin. These standards have been violated

by emissions from many mobile and stationary sources, including agricultural burning. The Federal Clean Air Act Amendments of 1977, which are implemented by the U.S. Environmental Protection Agency (EPA), require that all NAAQS be attained by 1982 unless a waiver is granted allowing postponement in so-called nonattainment areas until 1987. Substantial portions of the SVAB have been designated nonattainment areas for those pollutants generated by agricultural burning. The Clean Air Act further stipulates that state policies provide for both attainment and maintenance of standards to avoid financial sanctions from the federal government. These considerations, as well as continued pressure because of public health and aesthetic concerns, make it incumbent upon policymakers to consider possible policy alternatives.

### Policy options

Although final resolution of the problems related to rice straw burning await more thorough research and implementation of long-term solutions, there are several short-run policy options currently suggested: (1) To continue the present permissive burn/no-burn designations, but to restrict more severely or actually discontinue issuing variance exemptions, (2) to upgrade and increase the flexibility of ARB criteria designating which residues can be burned, and when and where, (3) to increase dramatically enforcement (primarily by local APCD's) of existing regulations, especially those relating to timing

and methods of open-field burning, (4) to establish an economic disincentive to burn in the form of a per-acre burn tax that could be administered within the purview of a "permissive burn" policy, and (5) to call for a ban on all agricultural burning.

It should be noted that these options are neither all-inclusive nor mutually exclusive. It is, in fact, likely that a short-run solution may involve a combination of approaches. Before any choice can be made, objectives must first be defined in the political arena. Questions of political, technical, and economic feasibility will be important. The economic impacts on rice producers (and, consequently, on input suppliers, processors, and other industry participants) must also be considered.

### Impacts of alternative policies

(1) To estimate the effect of policy option number one, reducing the number of variances issued, an analyst needs specific information regarding the number granted each year and the economic result if some or all of the waiver requests were denied. Economic impacts would depend upon the acreage and crop involved, and the nature of agricultural burning conducted under variances. Information as to estimated economic losses is not readily available, but ARB data do indicate an uneven distribution of variances among counties and a substantial increase in variance permits issued in recent years. In general, it seems likely that delays in proper field preparation resulting from variance denials or outright prohibition



Disposal of rice straw presents a major problem to producers. A swather windrows the heavy straw for baling.

will lead to increased producer costs.

Administrative and enforcement costs would probably decrease under a prohibition of variances since any burning on a no-burn day would be easy to identify as a violation. There could be a substantial positive impact on environmental quality: restrictions in granting variances could lower total emissions, especially on days exhibiting poor air quality, poor air dispersion capability, or inversion conditions.

(2) The second option, to upgrade and increase the flexibility of ARB designations, could result in substantially improved air quality. Criteria for designating burn/no-burn days — now dependent upon basin-wide meteorological and air quality information — could be made to vary by crop residue type, elevation, geographical region, humidity, and time of day. (The ARB is considering implementing some of these criteria in a revision of agricultural burning guidelines.) Specific residues would be burned at more appropriate times and places with substantially lower emissions. Burning could be limited to times when residue moisture content is sufficiently low, and to geographical areas where local atmospheric conditions favor burning. Such a policy would, however, entail increased costs for forecasting, administration, and enforcement. Costs to producers would depend upon the extent to which new regulations resulted in delays in burning and associated increases in field preparation costs. It is also likely that producers would view such a policy as inequitable, since burning regulations could not be applied uniformly among them.

(3) Increased enforcement of existing regulations, the third option, would also improve air quality. It has been estimated, for example, that increased enforcement of requirements for backfire and into-the-wind strip lighting techniques (instead of headfire burning) and waiting periods until straw is dry could reduce emissions from agricultural burning by 38 percent in Sacramento County. Effective prohibition of headfire burning can reduce particulate emissions by as much as 50 percent. Expanded enforcement would necessitate substantial costs — especially for the local APCD's. Since estimated per-acre costs are at least 16 to 25 cents for headfire, 33 cents for strip lighting, and 87 cents for backfire burning, changes in producer costs would depend on whether, and to what extent, a producer is currently abiding by existing regulations.

(4) Impact of the fourth option, a per-acre burn tax and continuance of the burn/no-burn regimen, would depend

upon the nature and the level of the tax. The important question here is: At what level would the tax have to be levied to induce changes in producer behavior — that is, how large would the economic disincentive have to be before producers stopped burning rice straw? The answer would depend upon the magnitude of the tax, the net cost of other straw disposal alternatives, and the profitability of cropping alternatives in cases where no alternative straw disposal method is feasible and land must be shifted out of rice production. A bill introduced by Assemblyman Greene (AB 681) would impose a \$2-per-acre tax on burning of field crop residues. Our analysis indicates that this level of taxation would do little to alter producer behavior.

Any impact on air quality under this option would depend on how much open-field burning is reduced. The impact on administrative and enforcement costs is also indeterminate, but burn tax revenues could be used to offset costs or to subsidize other straw disposal methods.

(5) The fifth policy alternative would lead to an absolute ban on all agricultural residue burning; the impact would depend on the alternative approach producers adopted. Soil incorporation and straw utilization are the only disposal systems which do not involve burning residues.

Soil incorporation requires more tillage to remove residue than if a field were burned. Extra costs of soil incorporation vary substantially, depending upon local soil characteristics, equipment used, and cultural practices employed. These extra costs can range from approximately \$5 to \$25 per acre under very good fall and spring tillage conditions. Incorporation in more difficult soil types or under wetter conditions could be expected to be much more expensive.

Other expenses are associated with soil incorporation. Experimental results indicate that in fields where rice was harvested at 8 to 12 inches, followed by incorporation of straw for three consecutive years, stem rot reduced yields an average 14 percent compared with fields in which the straw was burned. Using the average value of \$8.40 per hundredweight for rice during the test period (1975-1977), this yield reduction of 4.7 hundredweight per acre represents a per-acre revenue loss of approximately \$40 (or 8 percent) of the average total revenue per acre. Because stem rot severity increases over time, this estimate may overestimate costs during the first several years and underestimate costs for later years. This revenue loss added to the increased tillage costs of soil incorpora-

tion clearly means that this method of residue disposal is especially costly to growers.

Straw utilization is the other no-burn alternative. Rice straw has proven potential for cattle feed, fiber products, and fuel-related uses. Total costs to producers of any straw utilization scheme would depend upon the difference between the extra expenses associated with straw drying, removal, packaging, handling, and transportation, and the revenue derived from selling the straw. At present there are no widespread uses nor do there exist established, reliable markets to absorb a large volume of rice straw. Even with such markets, substantial problems, many weather-related, with field collection, handling, transportation, and processing need to be overcome.

## Conclusion

It is apparent that soil incorporation is the only *currently available* "no-burn" straw disposal method. This method can substantially increase costs to rice producers. This implies that a relatively small per-acre burn tax would be ineffective in significantly reducing the amount of burning. A relatively large burn tax would likely be required in most rice-growing areas before soil incorporation would be widely adopted or before growers would shift to alternative crops. The level at which such a tax would begin to induce shifts from growing rice depends upon the profitability of other uses of acreage now in rice. Unfortunately, much rice acreage is not particularly well-suited to cultivating other crops. Until straw utilization technologies and markets are adequately developed, a substantial burn tax or an outright ban on burning would probably reduce rice acreage and create a shift to other crops where feasible, rather than a major shift to other straw disposal methods.

Although short-term solutions have potential for improving air quality, most of the costs of these policies would be borne by rice producers who may not be able to pass them on to rice consumers. Since it is likely that agricultural burning will be severely restricted eventually, and since soil incorporation does not appear to be a viable long-run alternative, one may conclude that public support for the development and implementation of straw utilization schemes is necessary for the continued prosperity of California's rice industry.

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