AGRONOMIC CROP SCIENCE REPORT

Research Extension

EVALUATION OF A FIELD SANITIZER FOR CONTROLLED BURNING OF GRASS SEED FIELDS 1/

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The concept of a mobile unit that would burn straw and residue in the field under conditions that would minimize the visible emissions and retain the beneficial effects of open burning, was developed when it became apparent that the practice of open burning of grass seed straw was creating a major air pollution problem. In November of 1969, the Agricultural Experiment Station at Oregon State University accepted the assignment of developing and testing an experimental mobile field sanitizing machine within certain specifications established by representatives of the Oregon State Legislature and the Oregon grass seed industry. The basic specifications for the machine were 1) have a field capacity of 2.5 acres per hour; 2) have a burning capacity of 10 tons of grass straw residue per hour; 3) provide field sanitation through destruction of disease organisms and weed seed and provide physiological stimulus to perennial grass crops with a treatment that would equal or exceed that achieved by open field burning without excessive damage to plant stands; 4) operate within acceptable limints for smoke emission; 5) confine the fire spread to the immediate area under treatment; and 6) operate at the total cost of less than $10 per acre.

Data from the experimental machine constructed by OSU engineers were to provide the necessary design parameters of ignition fuel requirement, field residue burning rates, ground speed, thermal treatment, power requirements, process control, and limiting physical, geometric dimensions so that practical commercial field units might be constructed.

Agricultural engineers at the Agricultural Experiment Station developed a pilot stationary model for initial studies of burning characteristics, combustion box design, and stack emissions. A full-sized field machine was constructed in 1970 with a 12x16-foot open-bottomed firebox fitted with feed augers. Field testing revealed that the concentration of the flame above the grate resulted in delayed burning of the stubble on the soil surface. To provide more immediate ignition and rapid burning of the soil surface, an air duct system was devised. High velocity air jets were directed downward to dislodge loose straw and chaff from the soil surface and provide the necessary

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turbulence for rapid combustion. This design permitted all the burning to be done at the soil surface and eliminated any need for picking up straw and depositing it upon a grate.

The unit was again redesigned and tested in 1971 and 1972 with innovations to improve combustion, speed, and reduce fire spread. Beginning in 1972 an expanded series of tests to evaluate seed crop responses were initiated. Studies were conducted on bluegrass, orchardgrass, perennial ryegrass, tall fescue, fine fescue, and bentgrass, using variables of season of burn, moisture content of residue, speed of travel, and quantity of straw burned.

Temperature treatments were measured by observing thermocouples placed at the soil surface and by monitoring the temperature within the combustion chamber.

To provide for replicated field testing of crop response to thermal treatment provided by the sanitizer, a small machine with a 6-foot by 6-foot combustion chamber was constructed and mounted on a tractor three point hitch. Calibration tests were conducted on three species of perennial grasses in 1972-73 to determine if similar responses could be expected from the small unit and the large unit if ground speed were adjusted to provide similar exposure.

RESULTS AND DISCUSSION

Correlation of Plot Unit to Field Sanitizer

Tests on three species of perennial grasses indicated that comparable results could be expected from the field sanitizer and the plot unit if ground operating speeds were adjusted to compensate for differences in length of the firebox, thus standardizing exposure times. Visual comparisons and yield response were the same from the two units (see Table 1).

Table 1. Comparison of plot burner and field sanitizer, 1972-73.

Crop	Mean Seed Yield (lbs/acre) 3/	
	Plot Burner	Field Sanitizer
Merion Kentucky bluegrass	405	383
Potomac orchardgrass	936	1072
Linn perennial ryegrass		
Early season	391	440
Late season	469	558
Fawn tall fescue	903	882

3/ Mean of eight tests on each crop using three straw rates.

The plot unit has the distinct advantage of reaching a standardized box temperature within two minutes of operation, while the field unit requires five minutes.

Seasonal Timing of Treatment

The detrimental effect on seed yield from late-season open field burns has been reported by Dr. D. O. Chilcote.4/ Recommendations have been made to seed growers for early-season open burns to stimulate maximum seed yield. Early burns also have the advantage of producing less visible emissions which result from burning high-moisture regrowth that develops late in the season. Decreased seed yield from late burns is attributed to a greater plant susceptibility to thermal exposure after growth has been initiated. When this occurs, the plant's growing points are more sensitive and less protected, thereby increasing the chance of injury from thermal treatment.

Sanitizer treatments have also been found to reduce seed yields when treatments were applied in late season (late September and October). Although straw and stubble conditions are suitable for burning, plants are in a growth condition that makes them more subject to injury. Chewings and red creeping fescue varieties are most sensitive to late-season burns (see Table 2). No difference in yield was noted between September and October treatment in 1972-73 in tests on Potomac orchardgrass, Linn perennial ryegrass, fawn tall fescue, or Highland colonial bentgrass.

Table 2. Effect of date of burn treatment on seed production, 1972-73. Seed yield, pounds per acre.

Crop	Sanitizer Burn		Open Burn	
	September	October	September	October
Barfalla fescue	888	344	970	321
Merion Kentucky bluegrass	420	379	450	302

Thus plant growth stage dictates a seasonal operating limit for the field sanitizer on some perennial grass seed crops, particularly fine-leaved fescue. Fine-leaved fescue varieties must be sanitized immediately after harvest, even though later burns may be physically possible. Other grass species have a longer period over which they may be treated. The "cut-off" date may vary from season to season, depending upon the regrowth initiation which is influenced by the onset of rains coupled with lower mean temperatures.

4/ "Techniques and Timing of Post-Harvest Grass Seed Field Burning". Progress Report EXT/ACS 7, Agriculture Experiment Station, Oregon State University. D. O. Chilcote and H. W. Youngberg. March 1975.

Temperature Exposure and Fuel Conditions

The initial concept of the sanitizer was that it would be used for straw disposal as well as field sanitation. Propane or other supplementary fuel was to be used only for ignition and to sustain firebox temperatures under unfavorable conditions. This concept was modified when field trials showed that speed of operation was slowed because of the excessive heat produced by burning all of the straw. In addition, the anticipated increase in the market value of straw makes it seem inadvisable to dispose of this material in such a manner.

Field tests were conducted with all straw on the field, with straw removed leaving stubble for fuel, and at several speeds to evaluate the effect of sanitizer operation under extremes of field and fuel conditions.

At both normal and extra straw levels, the sanitizer had to be operated at lower speeds because of the excessive heat generated by the added fuel. Adequate fuel for field sanitation was provided for sanitizer operation with straw removed, leaving only the stubble that remained after the harvest operation.

Tests in the 1972-73 season indicated that perennial grass plants were very tolerant of the thermal exposure induced by the sanitizer. Temperatures as high as 1000°F measured at the soil surface for as much as 5 seconds have not severely injured stands which then produced seed yields comparable to open burns.

Both open-burn and machine-burn treatments produced higher seed yields than those in which the straw was raked off and the plots left unburned. Burn treatments produced seed yields 10 times greater than unburned treatments in Barfalla fescue (see Tables 3 and 4).

Table 3. Seed yields from open burns and machine burns compared to unburned treatments, 1972-73. Pounds seed per acre.

Crop	Open Burned	Machine Burned	Unburned
Merion bluegrass	367	380	282
Potomac orchardgrass	945	983	785
Linn perennial ryegrass	552	464	487
Fawn tall fescue	925	893	720
Barfalla fescue	645	609	306
Highland colonial bentgrass	314	342	262

Based on visual evaluation, the most effective treatments were those with maximum temperatures of 550-750 F with exposures of 10-15 seconds. However, the tolerable range of temperature and exposure time appears to be quite wide. This apparently depends on 1) the insulating properties of the dry plant tissue surrounding sensitive growing points, 2) the protection provided the temperature-sensitive growing points near the soil surface during summer dormancy, and 3) the controlled duration of the temperature exposure. Under certain conditions, moisture in the straw and leaf tissue would provide a large heat sink and modify temperature exposures.

The lower limits of acceptable treatments are those that completely remove the residue from upon and around the plant crown. Complete residue removal itself is apparently more critical than the temperature treatment per se in stimulating seed yield. However, this residue removal must be more complete than that provided by merely raking the residue from the field. These low-temperature treatments may provide physiological stimulation of plant growth and seed yield, but they may not completely destroy disease organisms and thus would fail to compare favorably with open field burning.

The machine burn produces a more uniform result than does open burning. Variations in fuel volume, distribution, and weather conditions affect the type of open burn produced. A more uniform treatment is produced by the ignition of the entire width of the sanitizer and by the radiation from the internal firebox surfaces. This factor is most significant in crops such as bluegrass that are difficult to burn because of higher moisture material in the post-harvest residue.

There were no diseases present in the plots to affect seed yields, thus disease control was not evaluated.

Species Response to Sanitizer Treatment

Perennial grass species and varieties differ morphologically. These differences can account for the varying species response to thermal treatment and to type of post-harvest residue removal, as shown in Tables 3 and 4.

Table 4. Seed yields from open burns and machine burns compared to unburned treatments, 1973-74.

Treatment	Newport Kentucky bluegrass		Linn perennial ryegrass		Barfalla fescue		Potomac orchardgrass	
	lbs/A	% Unb	lbs/A	% Unb	lbs/A	% Unb	lbs/A	% Unb
Open burn	1146	92%	1431	136%	477	994%	889	104%
Machine burn	1208	96%	1286	122%	400	833%	956	111%
Unburned	1250	100%	1050	100%	48	100%	858	100%
$LSD_{.05}$	125		108		45		89	

There are indications that under optimum operating conditions some crops (i.e., Merion bluegrass, 1970-71) will react more favorably to a sanitizer treatment than to an open burn (see Table 5). This observation has not been consistent, however.

Three years of tests have shown that the field sanitizer will produce seed yields equivalent to open field burns over a wide range of operating conditions. Seed yield increases have been obtained under certain conditions.

Table 5. Merion bluegrass seed yield under various residue treatments.

Treatment	Seed yield (as % of open burn)	
	1970-71	1972-73
Sanitizer	127	103
Open burn	100	100
Unburned	40	77

SUMMARY

The field sanitizer concept has undergone four years of field evaluation under a wide range of operating conditions. The sanitizer has met emission standards established by the Oregon Department of Environmental Quality. Firebox temperatures can be maintained without supplementary fuel except during adverse conditions. Field tests to date have indicated that the sanitizer will stimulate seed production as effectively as open burning has in the past, but the sanitizer has failed to increase seed yield sufficiently to offset its increased operation costs as compared with open burning.

OUTLOOK

A number of problems remain to be solved before the machine burning replaces open field burning. Field-scale machines have not yet been operated for sufficient time to determine all costs. The length of the operating day and the season are limited, increasing the hourly overhead cost. Machine and firebox wall-lining-life is yet to be determined under sustained operating conditions. The capability to manufacture a large number of machines with a low obsolescence factor has yet to be established.

Whether these questions can be satisfactorily answered and this concept can become a viable part of seed production in an environmentally conscious era is yet an engineering and economic question.