Quantifying Emissions from Burning Kentucky Bluegrass Seed Fields

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Open-field burning of bluegrass post-harvest residue

Introduction

Fire has long been used as a management tool in grass seed production (Hardison, 1980). However, concerns over the health impact of emissions from open-field burning have pointed to the need for information on the composition of grass fire emissions. Residue reduction (baling) followed by diesel or propane flaming may reduce emissions while maintaining good seed yield (Johnston, 1997). Characterization of emissions from the current grower practice of "bale and burn" of Kentucky bluegrass (*Poa pratensis* L.) post-harvest residue is needed. Smoke reduction and management should be based on total emissions rather than number of acres burned.

Objectives:

1. To characterize post-harvest residue and field conditions of Kentucky bluegrass seed production fields at the time of burning.
2. To quantify, under field conditions at dryland and irrigated sites, with and without post-harvest residue removal, the quantity of emissions generated during field burning and relate to conditions evaluated in Objective 1.

Materials and Methods

Three 12-ha Kentucky bluegrass seed field sites were chosen during spring 2001; an irrigated field at Connell, WA, a dryland field at Worley, ID, and an irrigated field at Rathdrum, ID. Two residue treatments were evaluated at each site: a no post-harvest residue removed treatment (high, i.e., "full load") and a pre-burn baling of post-harvest residue (low, i.e., "reduced load"). Each residue treatment consisted of three separate 1.6 ha burn units (replications) at each site.

The pre-burn surface fuel load and canopy architecture within each burn unit was characterized. Residue load (residue dry weight) was determined by clipping samples at eight random locations within each burn unit.

Immediately prior to each burn, samples were taken at four random locations within a burn unit to determine moisture content of grass residue and the upper 5-cm soil layer. Characteristics of each burn were documented: date and time of burn, ignition pattern, air temperature, wind velocity, wind direction, and relative humidity. Following each burn, residue samples were taken at four random locations within the burn unit to determine post-burn residue remaining.

Emissions monitoring was performed using the Missoula Fire Science Laboratory's Fire-Atmosphere Sampling System (FASS). Two instrument towers (sub-samples) were erected on each plot. The computer control system, battery, pumps, flow meter, manifolds, particulate filters, gas collection, and real-time analyzers were buried near each instrument tower. The emission species characterized were: CO, CO_2, CH_4, $PM_{2.5}$, PM_{10}, Benzo(a)pyrene (BaP), and six BaP-equivalent carcinogens [benzo(a)anthracene, benzo(b)fluroanthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and idenol(1,2,3-cd)pyrene].

Low residue load at Worley, ID

Low residue burn at Worley, ID

High residue load at Worley, ID

High residue burn at Worley, ID

Fire-Atmosphere Sampling System

Results and Discussion

Residue Loading: The high (i.e, no residue removed) and low (i.e., residue removed by baling) residue loading means averaged over all sites were 8982 and 4042 kg ha^{-1}, respectively. Pre-burn residue loading did not influence post-burn residue remaining.

Residue Consumption: Absolute residue consumption ($RC_{Absolute}$) was the same for high residue loading at all sites, approximately 7185 kg ha^{-1} (Fig. 1). The Rathdrum low residue loading treatment was unique and $RC_{Absolute}$ was greater than at the other sites. There was a strong positive relationship between $RC_{Absolute}$ and the pre-burn residue loading. This would suggest that any practice that removed a significant portion of the post-harvest residue from a bluegrass seed production field (e.g., baling) would reduce the amount of residue consumed.

Emission Factors for $PM_{2.5}$, CO_2, CO, and CH_4: $EF_{PM2.5}$ for Connell high residue loading (n=1) was numerically greater than Rathdrum and Worley high residue loading. At Rathdrum and Worley, low pre-burn residue loading produced consistently greater $EF_{PM2.5}$ than high residue loading (Fig. 2). There was a strong positive relationship between EF_{CO2} and CE (Combustion Efficiency, %). There were also strong negative relationships between CE and EF_{CO} and EF_{CH4}. These relationships are similar to those reported for other studies (Air Sciences Inc., 2003).

Emission Factors Affected by Residue and Soil Moisture: There was no relationship between residue moisture content and $EF_{PM2.5}$. EF_{CO2} decreased with increasing residue moisture content, while EF_{CO} and EF_{CH4} increased with increasing residue moisture content. None of the pollutant emission factors was significantly related to soil moisture content.

Emissions Factors for Polyaromatic Hydrocarbons (PAHs): PAHs were detected in only two sub-samples. At Worley high residue loading, benzo(a)anthracene and chrysene ranged from 0.39 to 0.42 mg kg^{-1} of residue consumed and benzo(b)fluoranthene 1.6 mg kg^{-1} of residue consumed. These values are in the range reported for other crops (Ramdahl and Moller, 1983; Jenkins et al., 1996a, 1996b, and 1996c).

Total $PM_{2.5}$ Emissions: Baling followed by open-field burning (propane flaming at Connell) significantly reduced total $PM_{2.5}$ at Worley and and Connell (n=1) (Fig. 3). At Rathdrum, baling did not reduce total $PM_{2.5}$ emissions relative to burning of the high residue load. Higher $RC_{Absolute}$, potentially leading to higher total emissions was compensated for by a lowered $EF_{PM2.5}$ at high residue loading at Rathdrum. $RC_{Absolute}$ and $EF_{PM2.5}$ combined explained 95% of the variation in total $PM_{2.5}$ emissions. Individually, $RC_{Absolute}$ and $EF_{PM2.5}$ explained 21 and 45%, respectively, of the variation in total $PM_{2.5}$ emissions per ha.

Conclusions

- High pre-burn residue loading had significantly more residue on the field than the low loading residue treatments.
- Residue consumption increased with pre-burn residue loading. The implication is that baling is an effective method to reduce residue consumption.
- There were no relationships between residue consumption and residue or soil moisture or any environmental factor monitored.
- Both $RC_{Absolute}$ and $EF_{PM2.5}$ are required to predict total $PM_{2.5}$ emissions at any site.
- At Rathdrum, ID (irrigated site) baling did not reduce total $PM_{2.5}$ emissions, while at Worley, ID (dryland site) baling significantly reduced total $PM_{2.5}$ emissions by 66%. At Connell, WA (irrigated site), baling followed by propane flaming numerically (n=1) reduced total $PM_{2.5}$ emissions by 91%.
- Residue stratification (residue architecture above the soil surface) and the bulk densities of the residue layers may affect $RC_{Absolute}$, $EF_{PM2.5}$, and total $PM_{2.5}$ emissions. This is an area for additional research.

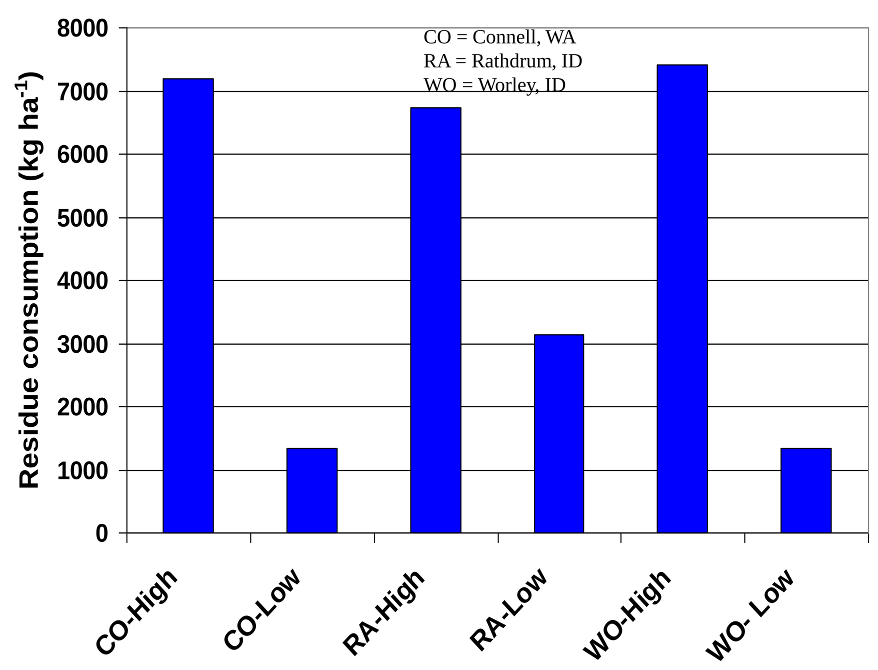

Fig. 1. $RC_{Absolute}$ by site and residue loading.

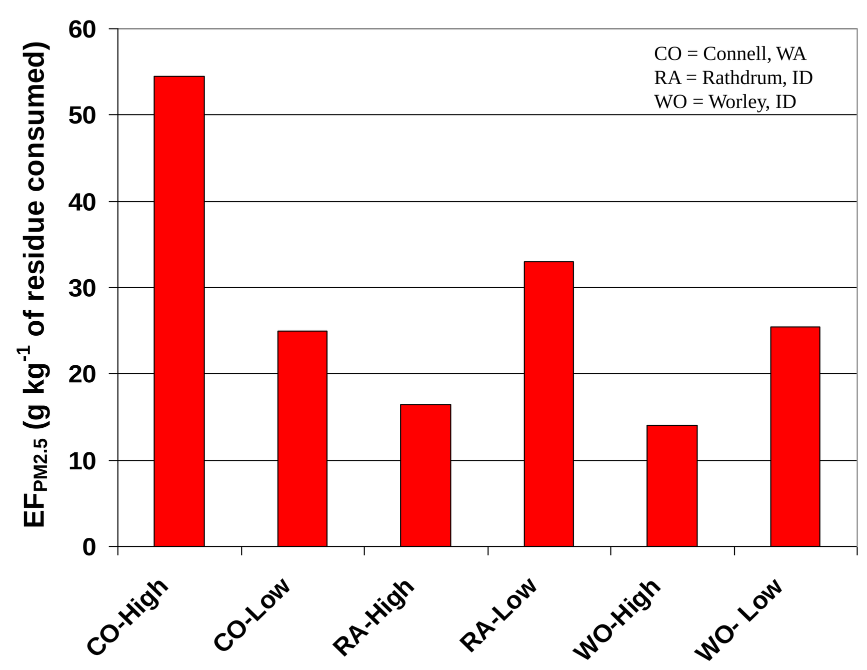

Fig. 2. $EF_{PM2.5}$ by site and residue loading.

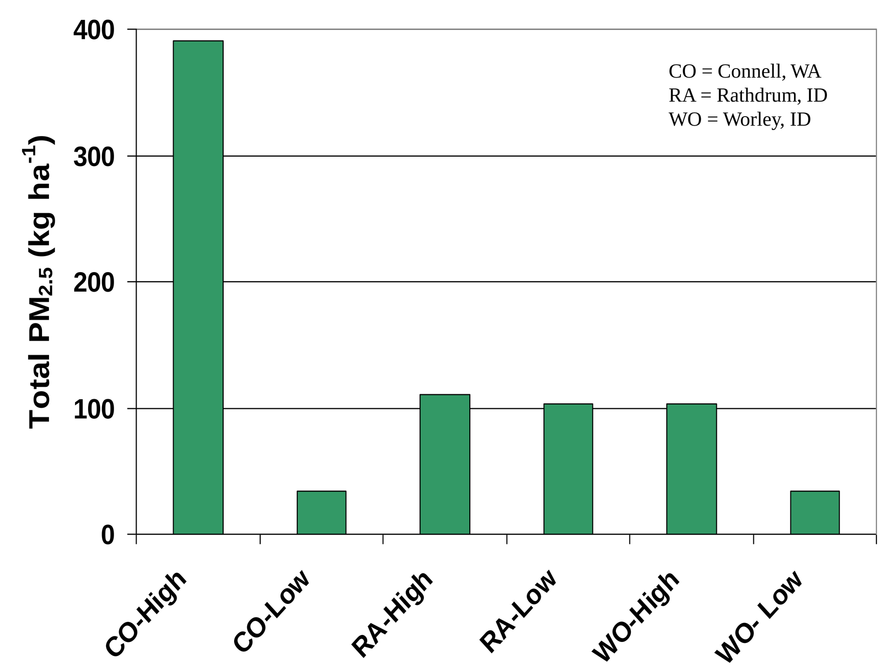

Fig. 3. Total $PM_{2.5}$ by site and residue loading.

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