Prescriptions for

Woody Biomass Reduction

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Air Curtain Burners: An Innovative Alternative to Chip & Till Prescriptions for Woody Biomass Reduction

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Introduction

There are air quality regulators in the western US encouraging agricultural land managers to reduce wood waste by chipping and incorporating wood chips into orchard or farm soils rather than burning the wood. For those with the immediate concern of avoiding emissions (PM2.5 & gases), this may seem like a reasonable and fast disposal prescription (out of sight out of mind). Unfortunately, this prescriptive method may hold unintended consequences to soil nutrient availability, leading to cumulative effects that may reduce farm yields. When an organic material with a high carbon to nitrogen ratio (C:N) is introduced into the soil, it can limit plant available nutrients and thus affect crop yields.

In the absence of a full Life Cycle Assessment (LCA), this brief report attempts to explain how and why this may not be an appropriate method of disposal and offers an adaptation to existing burning which may meet the goals of all involved.

Background

Biomass can steadily accumulate in fruit and nut orchards as result of the yearly pruning required for tree health and vigor or accumulate quickly if a change in the desired crop requires the extraction of the orchard. Often demand in the consumer market or water regulation can drive such decisions (Hester, 2021, Kushman, 2022 and Bland 2023), in addition to the effects of Climate Change.

All organic matter is ultimately potential soil and woody material is not the exception to that rule, however, of all of the ingredients to make soil, wood takes the longest to decompose. Wood left whole and on the surface of the soil can take 50-100 years to decompose, depending upon factors like species of the wood, its density and the woods exposure to the decomposing elements like temperature and moisture (Gough, 2007). Regardless of the reason for the accumulation of wood, because it is slow to decompose often a faster disposal method is needed once the amount reaches a tipping point. Not many farmers have acres of land not in production to store wood, since they rely on the entirety of their available farmland to remain financially solvent. Few farmers have the operational space to wait out decomposition of wood or compost it, before using it as a soil amendment; nor are they willing to risk the liability of having piles of wood vulnerable to wildfire. Typically, wood piles are burned but regulators are concerned with smoke and emissions, hence their desire for chip and till as a fast and smokeless means of disposal.

Figure 1 An aerial view of rows of uprooted almond trees during a May 2021 orchard removal project in Snelling, California. Justin Sullivan/Getty Images (Hester 2021)

Reducing the size of wood by chipping speeds up the decomposition process. Once chipped, there is a greater surface area exposed to the elements and decomposers (bugs and fungi) accelerating the decomposition. Similar to composting, if the wood is then placed in a consistently moist environment (Gough et al., 2007); the combination of increased surface area, water and biologic activity from decomposers accelerates the production of soil. This is where the Chip & Till prescription falters, while it is out of sight and mind, it can still have unintended consequences.

Since their objective of smokeless disposal has been achieved, air regulators seem to end the prescriptive effects assessment at this point and fail to analyze the effects of wood chips on soil health. The prescription's problem is the assumption that the wood will add to the soil's productivity immediately and not have a potentially short-term detrimental effect. Unfortunately, it is also the part of the prescription that has the greatest potential consequence to a farmer surviving from year to year on crop yields that can rise and fall based on the plants ability to access nutrients.

As previously mentioned, wood has the highest carbon to nitrogen ratio of all plant matter. Organic soil amendments such as compost, typically have a recommended C:N ratio of 30:1 (Cornell University). When wood chips with a potential C:N ratio of 500:1 is added to the soil, available nutrients may be reduced as the soil biota works to overcome the new high carbon food source The size of the wood chip also plays an integral role in the process. The larger the wood chip, the longer it will limit plant available nutrients. So, if wood chips are utilized as a soil amendment, the finer the wood chip is in size, the less amount of time it will limit plant available nutrients. An economic factor to consider is that smaller wood chips cost more to produce. While it may be possible for farmers to add wood chips to the soil in active fields with minimal to no effects to acre yield, it would require intensive soil testing and likely the application of fertilizers to overcome the effects of the wood chip additions.

Air Curtain Burners - An Innovative Alternative

When wood decomposes, the carbon collected during its life cycle is released forming the gases; carbon dioxide (CO_2) and methane (CH_4) (Kipping et al. 2022). Biomass can be consumed by either flora and fauna living in the soil, or during controlled or uncontrolled burning. Burning also can produce a fine particulate (PM2.5) which is taken aloft in the rising smoke. The production of smoke and PM2.5 are the issues of concern for the air quality agencies.

As an alternative to the Chip and Till prescription, Air Curtain Incinerators (ACIs), can be utilized. ACI equipment is a low-smoke disposal option, that can capture carbon through the formation of charcoal; reducing Greenhouse Gas (GHG) emissions in agriculture. When an ACI like the BurnBoss or CharBoss are used; the volatile gases released from wood are largely consumed with the creation of the charcoal, an agriculturally viable product. These two mobile ACIs have the ability to minimize carbon loss by keeping it in the form of charcoal, thereby preventing carbon from compounding with oxygen to form CO_2. While tilling in the chipped wood typically delays the release of carbon in the form of CO_2 as it takes time for decomposers to break down the material. As the decomposers respire in the soil, they also release methane CH_4; which is a far more potent Greenhouse Gas (EPA 2023). By converting the wood to charcoal with an ACI, carbon stored in wood is stabilized.

Testing by the USFS Rocky Mountain Research Station has determined that the resultant charcoal is greater than 80% carbon. The brittle charcoal may weather (freeze/thaw or crushing) into smaller particles, but it has a low likelihood of being taken up by plants, which gain carbon in the form of CO_2 gas. When added to soils limited by available water and plant-available nutrients, this sequestered carbon can bring improved productivity to some farm soils. Therefore, we can assume the conversion process of stabilizing carbon as a charcoal, then using it as a soil amendment; is a form of carbon capture. To summarize the process, woody farm plants acquire the carbon from the atmosphere, the ACI coverts the plant material into stabilized carbon in the form of charcoal before it can be loss to wildfire or decomposition.

It can then it can be utilized to increase soil productivity. Both ACI's operate at temperatures sufficient to kill all plant diseases and pests. ACIs provide a long-term benefit to farms.

The BurnBoss produces charcoal in batches and was originally designed to burn material to ashes. The BurnBoss can produce only small batches of charcoal. In contrast, the CharBoss continually produces charcoal as new wood is placed into the equipment. In recent testing, the CharBoss was estimated to have a conversion rate of 30% producing 600 pounds of charcoal per ton of wood. While the BurnBoss and the CharBoss both are efficient at reducing biomass, the CharBoss has the added benefit of producing charcoal in quantities sufficient to be marketed to farmers or others.

Within the burn chamber of the ACIs, the heated wood forms charcoal on the wood surface and volatile compounds are released. As charcoal forms on the surface of the wood and the exothermic reaction moves into the wood, charcoal is exfoliated further exposing the heated wood to form more charcoal. The difference between the ACIs is that the CharBoss accelerates the process by adding agitation to the burning wood, so brittle charcoal is rubbed free and drops out of the burn chamber to be extinguished in a water bath. This quenched charcoal is stable and no longer able to bond with either oxygen or hydrogen to form CO_2 or CH_4.

The charcoal (biochar) made from the ACI units has been seen to increase both water and nutrient holding capacities in the soil. It can be added to other organic amendments or used alone as an amendment. Applications of unamended biochar can be timed to crop dormancy or blended with other organic amendments (mulches, manures…) to offer the greatest benefits to a given soil type.

Conclusion

With the potential for the Chip & Till to limit crop yields, it may be prudent for farmers with excess wood to consult on soil productivity risks as well as obtain information on alternative methodologies. Consultation with NRCS (USDA-NRCS) or the Agricultural Research Services (USDA-ARS); for site-specific soil recommendations is suggested. These government agencies also have new programs that may help farmers to pay for the conversion of wood to charcoal for soil amendments. This work is eligible to be funded through USDA programs (CSP 384A – Biochar Production from Woody Residue) as the benefits of biochar are recognized by both federal and state agencies.

The CharBoss offers a methodology that could reduce regulatory concerns of smoke and other emissions while also meeting the soil health objectives through funded USDA programs.

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