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Utilization of Composted Mulch for Erosion Control in Hillside Vineyards

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Abstract
Composted mulch was applied in vine rows planted up and down slope in four vineyard sites to investigate the effects on sediment loss. At each site, nine contiguous rows were selected for uniformity in slope, soil texture and soil structure, pore size and percent rock fragments. Plots were installed in each vine row and mulch was applied to create three replications of three treatments in a randomized complete block design. Treatments and trial design were identical in all four vineyards. In vine rows designated as Treatment 1 and 2, composted mulch was applied to a 3" depth in December 1999. In December 2000, Treatment 1 vine rows received 1.5" of additional mulch. Rows designated as Treatment 3 were left untreated. The average percent reduction in sediment collected in vine rows that contained mulch as compared to the controls ranged from 78% to 98% over the 4 sites in the 7 month period that ended in May 2001.

In one vineyard, a rainfall simulator was designed and built to provide a precipitation rate very close to that produced in a 2 year, 6 hour storm (2.4" of rain per event). NOAA “storm maps” indicate that a storm of that duration and intensity is the “average storm” most likely to occur in the vicinity of that vineyard over any two year period which will produce measurable erosion. The simulator was installed over all nine plots. Sediment yield and runoff volume were measured in March and April 2001, in 4 and 6 hour simulated storm events respectively. For the 4-hour storm, the average percent reduction of sediment generated in Treatment 1 and Treatment 2 mulch plots as compared to control plots was 85.0% and 54.7% respectively. In the 6-hour storm, the average percent reduction of sediment generated in Treatment 1 and 2 mulch plots as compared to control plots was 77.4% and 69.1% respectively.

Additional evaluations of the effect of an increased percent cover (by the use of mulch in vine rows) on soil erosion were conducted by using the Revised Universal Soil Loss Equation (RUSLE), which is a predictive model that estimates long term average annual soil loss. The model was run using site-specific data collected from each vineyard. For each site, a term in the model was varied to reflect the presence or absence of mulch in the vine row. Given the differences in soils, intensity and duration of average storm events in the vicinity of each vineyard and slope at each site, the RUSLE predicted a consistent range of 90% to 90.4% reduction in soil loss when mulch was present.

In 1999 and 2000, crop yield parameters and vine growth were measured in vines located inside and immediately adjacent to the plots in two vineyards. No significant differences were detected in yield or growth during the project. Berry samples collected by plot at both sites just prior to harvest each year also showed no effect of the presence of mulch on fruit composition (°Brix, pH or titratable acidity). Soil and vine tissue samples were taken by plot in all four vineyards and there were very few differences among the treated areas in any given site.

Introduction
This research and demonstration project was funded by the California Integrated Waste Management Board to determine if mulch derived from partially composted yard waste could successfully reduce

soil erosion in hillside vineyards. Counties and municipalities statewide are under legislated deadlines to reduce the waste stream to landfills thus there is a great deal of interest in diverting yard debris from those sites and developing new markets for its use. **Table 1** is a list of the agencies and companies that participated in the project.

Soil erosion from hillside vineyards has always been a concern of growers, as well as resource and regulatory agencies. It is a natural process, however human activities, ranging from agriculture to urbanization, often accelerate it with activities such as cultivation and modification of natural storm runoff. When rain is not absorbed into the soil, water will run off the slope carrying with it detached soil referred to as sediment. The amount of runoff and sediment it holds is a function of the physical properties of the soil including texture and structure as well as slope, rainfall intensity and duration. Organic matter present in soil will also affect runoff since it promotes stable soil aggregates, which increase infiltration. Surface water quality is degraded when land use practices result in increased runoff and sediment delivery.

This project was designed to demonstrate the effect of increasing percent ground cover in vineyards on soil erosion with the use of an organic mulch and to expose growers to a new product for this purpose.

Treatments

Treatment 1 – a layer of three inches of composted mulch was applied in the first year (December 1999) and one and a half inches of material was re-applied the second year of the project (December 2000).

Treatment 2 – a layer of three inches of composted mulch was applied in the first year (December 1999) and no additional treatment was applied in the second year.

Treatment 3 – is the control and no mulch was applied either year.

The composted mulch used in this project was created from self-haul yard waste, which is delivered to the composting facility by landowners and landscape contractors. It has very few foreign objects and has a higher ratio of brush to leaves thus it produces a coarser mulch product high in carbon content. A high carbon mulch is fungal dominated and therefore tends to enhance the stability of soil aggregates which improves infiltration. The mulch also serves to physically retain a portion of the rainfall that might otherwise become runoff. The mulch was treated with a pathogen reduction process whereby the temperature was held at no less than 131° F (55° C) for 15 days and the mulch turned at least 5 times during that period to ensure that all material had been exposed to the thermophilic temperature regime. Weed seeds were also killed by this process. In order to facilitate proper spreading, the mulch was screened to no coarser than two-inch minus with moisture content of 35 to 55%. A finer particle size would break down too fast and coarser material would be difficult to spread.

The mulch was applied in the vine rows with a Millcreek Row Mulcher and a Whatcom Northwest Mulch Spreader. To insure uniformity inside the plots, the mulch was applied by hand with five-gallon buckets inside the plots to the depth specified by the assigned treatment.

Plot Sediment Yield Measurements
All plots measured 29 feet long and 24" wide with the exception of one site that had narrow vine rows therefore the plots were 18" wide. A metal border was installed on the perimeter of the plot with a design that eliminated the risk of water or sediment passing in or out of the contained area. **Figure 1** is a plot diagram. A sediment trap on the down slope end of each plot caught all of the sediment from the contained land surface inside the plot. Sediment traps were 8 inches deep, 24 (or 18) inches wide and 6 inches long. The traps were fitted to match the degree angle of the slope of each of the vineyards (7% to 31%). On the down slope side, an overflow pipe was installed to allow water to flow out of the trap. The overflow pipe was fitted with a 90º, two-inch diameter elbow to prevent debris from clogging the opening. A small hole was drilled in the top of the elbow to prevent an air trap from forming. Overflow socks were installed on all sediment traps during the second year of the project. (The socks were not fabricated in time for use during the first year of the project.) The sock was attached to the overflow pipe to collect sediment suspended in the water that flowed through the pipe and entered the sock **(Figure 2A and 2B)**.

In the winter of 1999/2000 sediment was removed and collected from individual sediment traps after a variable period of time that spanned one to three rainfall events. In the following rainy season, sediment socks were used and these were also replaced on the same date that sediment was removed and collected from the traps. Sediment and overflow socks were air-dried and the net weight of sediment collected per plot recorded. **Figure 3** shows the reduction of sediment collected in the mulch plots as compared to the controls in Vineyard 2 in 2000-2001.

Rainfall Simulator
The rainfall simulator used at one vineyard site allowed researchers to measure that site's specific, episodic response to a simulated rain event. The plot sediment yields described above were not rain event specific, and runoff was not measured. Storm simulations allowed for direct measurement of runoff volume and the sediment contained in the runoff.

The simulator consisted of pressure compensating micro-sprinklers, attached to poly tubing secured to the upper foliage trellis catch wire spanning all nine vine rows that contain the plots **(Figure 4)**. To achieve the desired precipitation rate, Agrifim MFA adjustable microsprinklers were spaced every 4 feet above the plots. To account for expected variation in precipitation on the ground due to wind and pump pressure variation, 4 collection cans were randomly set about each plot to measure precise output. Covers were placed on all sediment traps so that precipitation could not directly enter the traps – thus only runoff entered the traps.

Soil profiles were pre-wet to field capacity (but not saturated) approximately 24 hours prior to the simulation to create antecedent moisture conditions assumed in predictive soil loss equations, including the RUSLE. Immediately following the sprinkler run, rainfall depth was measured in the cans, and quantities of both sediment and runoff were measured in the traps. **Figure 5** shows the relative reduction of soil loss in the mulch plots as compared to the control for the 4 and 6-hour simulations. The differences in sediment yield between plots that had mulch and those that were exposed is an indication of the mulch's ability to absorb and capture rainfall that might otherwise become mobile and detach and transport soil particles.

RUSLE

The Revised Universal Soil Loss Equation is a soil erosion-model created to predict long-term (30 years) average annual soil loss due to detachment and movement of soil particles resulting from raindrop splash and runoff given specific site factors in a crop management system. It does not represent soil loss from an individual season. The RUSLE for calculating annual soil loss from a hillslope is **A=RK (LS) CP** where **A** is average annual soil loss, **R**=rainfall-runoff erosivity factor, **K**=soil erodibility factor, **L**=slope length factor, **S**=slope steepness factor, **C**=cover management factor and **P**=the conservation practice factor that accounts for farming practices that might serve to attenuate sheet flow across the land.

For each vineyard, the RUSLE was run twice to compare the existing cropping system (benchmark) with the proposed cropping and management system – the latter incorporating the practice of applying mulch in the vine rows. Site specific factors were used for each vineyard: long-term weather data was used to estimate R (including the 2 year, 6 hour storm event) whereas K and LS were measured **(Table 2)**. The P factor was held constant at 1.0 for all sites since row orientation was not modified. The benchmark cropping system was defined as an existing three-year old vineyard with a C factor that corresponded to a 10% ground cover in the vine row, which is non-tilled, and a 30% raised canopy. The same benchmark was used for all vineyards. The proposed management system was defined as a three-year old vineyard with a C factor that corresponded to an 85% ground cover in the vine row and a 30% raised canopy. **Figure 6** provides a side by side comparison of the percent reduction of soil loss as predicted by RUSLE when mulch is applied to vine rows and the reduction in sediment collected in mulch plots compared to control plots at each site.

Conclusions

Simulator data demonstrated that composted mulch placed in the vine row reduced sediment output. In most cases, runoff was lessened, but this aspect of the study will need further examination. Composted mulch provided a protective cover for the soil surface, reducing raindrop splash action and detachment of soil particles. Reduction of splash action also helps to lessen crusting and compaction of the soil surface. By increasing the percent cover in the vine row, the estimated annual soil loss was significantly reduced when compared to vine rows that have very little cover as predicted by the RUSLE analyses of each site.

There were large differences in sediment collected from plots with mulch as compared to control plots and these differences are consistent with findings obtained by the rainfall simulator and the use of the RUSLE. As seen in the photos presented today, the sediment collected from sediment traps was substantial since it is very likely that the soil movement (erosion) that occurred within the plots was all delivered to the traps. This “100% recovery” would only occur in small plots such as the ones used in this project. In the real world, as the drainage area increases, less is delivered from any given site because of the effects of time and spatial transport on the sediment, as well as storage and attenuation imparted by natural complex land surfaces and slopes. However, in spite of the fact that not all of the eroded sediment is transported and delivered to a sediment monitoring point such as a stream, this project demonstrates that far less would be eroded in the first place when a significant amount of the vineyard floor is covered.