Compost Amendment for Co-Management

O'AHU RESOURCE CONSERVATION & DEVELOPMENT COUNCIL

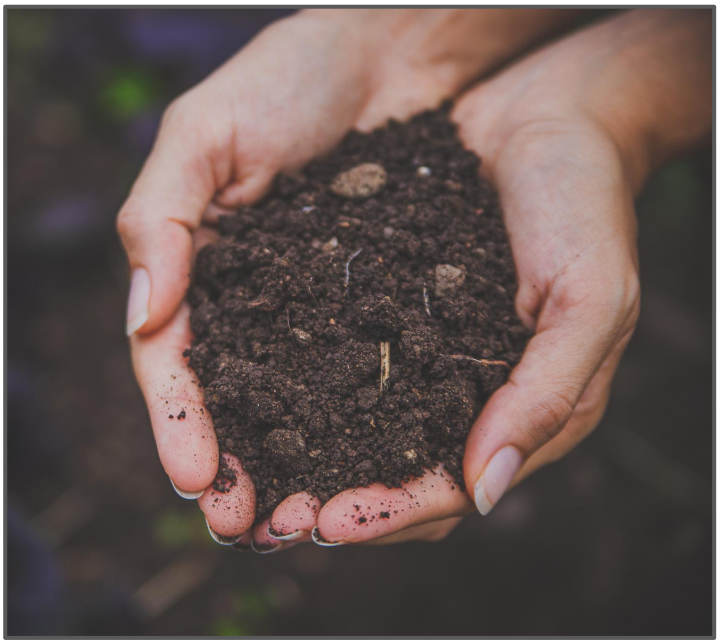
October 2020

COOPERATIVE EXTENSION
UNIVERSITY OF HAWAI'I AT MANOA

Co-management:
Refers to managing farms and their surrounding environments such that multiple goals are achieved: natural resource conservation *and* food safety.

Co-management practices:
Refers to those *best management practices* (BMPs) which meet objectives in both natural resource conservation and food safety.

Compost Amendment: Application of decayed organic carbon-rich material with many microbiological, structural, and fertility benefits for soil.



Soil from an organic farm in Waianae, Oahu

How does compost help?

Compost amendments improve soil health and soil biodiversity, helping to encourage microbial diversity and competition that suppress pathogens. Compost can improve soil structure, leading to increased infiltration of water and reduce the risk of potentially contaminated runoff or irrigated water to come in contact with produce.

Functions

- ➔ Increased microbial biodiversity
- ➔ Improved soil structure
- ➔ Increased water holding capacity
- ➔ Increased available nutrients

Best use: *Good for farms that need to improve soil health and function.*

Benefits

...to food safety

- Balancing/suppressing populations of human pathogens

....to conservation

- Building soil carbon and health
- Improved drought resistance
- Improved nutrient availability

Practicality

the pros

- Reduced need for fertilizer
- Compost tea is convenient to add into drip irrigation
- Long term benefits, requiring infrequent application in subsequent years

the cons

- May be too expensive/labor intensive for large scale operations
- Using an unfinished compost or improper application can pose food safety risk

Literature Summary

- *E. coli* O157:H7 growth in compost was negatively correlated with higher indigenous microorganism populations (Kim et al. 2011).
- Pathogens did not survive in stabilized compost with high indigenous microorganism populations, compared with sterilized compost (Paniel et al. 2010).
- Higher soil organic matter and moisture content, soil microbial diversity, and lower soil pH suppress *E. coli* abundance in the soil (Williams et al. 2015; Xing et al. 2019).

References

Kim, J., C. Miller, M. Shephard, X. Liu, and X. Jiang. 2011. Impact of indigenous microorganisms on *Escherichia coli* O157:H7 growth in cured compost. Bioresource Technology 102: 9619–25.

Paniel, N., Rousseaux, S., Gourland, P., Poitrenaud, M., and J. Guzzo. 2010. Assessment of survival of *Listeria monocytogenes*, *Salmonella Infantis* and *Enterococcus faecalis* artificially inoculated into experimental waste or compost. Journal of applied microbiology, 108(5), 1797-1809.

Williams, M., LeJeune, J. T., and B.M. Gardener. 2015. Soil conditions that can alter natural suppression of *Escherichia coli* O157:H7 in Ohio Specialty Crop Soils. Applied and environmental microbiology, 81(14), 4634-4641.

Xing, J., Wang, H., Brookes, P. C., Salles, J. F., and J. Xu. 2019. Soil pH and microbial diversity constrain the survival of *E. coli* in soil. Soil Biology and Biochemistry, 128, 139-149.

Cover Crop for Co-Management

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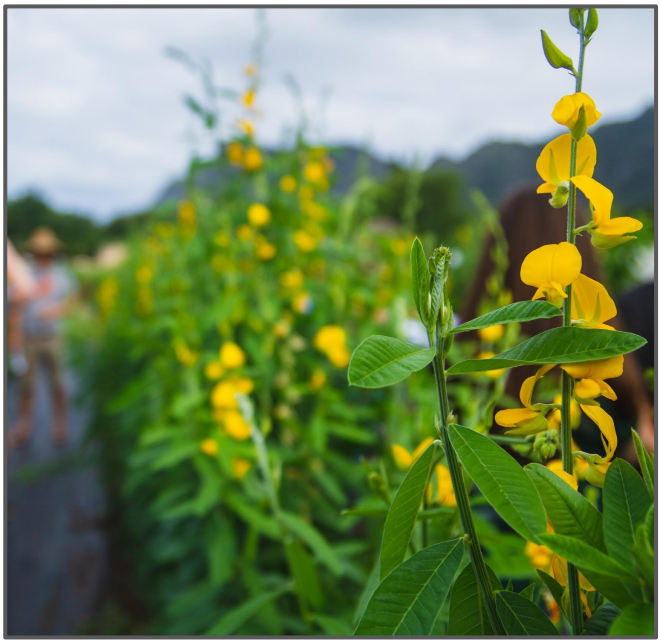
Cover crops: Grasses, legumes, and forbs planted for seasonal vegetative cover and encouraging beneficial insects.



Sunn hemp growing in Windward Oahu

How do cover crops help?

Improves soil health and soil biodiversity, helping to encourage microbial competition that suppress pathogens. Cover crops can also improve soil structure, leading to increased infiltration of water and reduce the risk of potentially contaminated runoff or irrigated water to come in contact with adjacent cash crops. Some cover crops are also effective at increasing nutrients in the soil.

Functions

- ➔ Increased plant and microbial biodiversity
- ➔ Improved soil structure
- ➔ Increased water infiltration
- ➔ Increased available nutrients

Best use: *Good for farms that need to improve soil health, reduce fertilizer input, and attract beneficial insects.*

Benefits

...to food safety

- Balancing/suppressing populations of human pathogens
- Reducing potentially contaminated runoff or standing water

....to conservation

- Building soil carbon and health
- Reducing runoff and soil erosion
- Improved drought tolerance
- Improved nutrient availability

Practicality

the pros

- Reduced need for fertilizer
- Suppression of crop pests
- Reduced erosion and increased infiltration

the cons

- Uncertainty regarding which cover crops will best compliment the farmer's goals
- Using a cover crop incorrectly can be detrimental to the cash crop
- Lack of equipment for seeding and/or removal
- Cost and availability of seed

Literature Summary

- Glucosinolate compounds from Brassica cover crops and residues have an antibacterial effect on Salmonella and E. coli O157:H7 (Patel 2013).

- Higher soil organic matter and moisture content, soil microbial diversity, and lower soil pH suppress *E. coli* abundance in the soil (Williams et al. 2015; Xing et al. 2019).

References

Patel, J. 2013. Glucosinolate-derived compounds as a green manure for controlling *E. coli* O157:H7 and *Salmonella* in soil. Center for Produce Safety Interim Report.

Williams, M., LeJeune, J. T., and B.M. Gardener. 2015. Soil conditions that can alter natural suppression of *Escherichia coli* O157:H7 in Ohio Specialty Crop Soils. Applied and environmental microbiology, 81(14), 4634-4641.

Xing, J., Wang, H., Brookes, P. C., Salles, J. F., and J. Xu. 2019. Soil pH and microbial diversity constrain the survival of *E. coli* in soil. Soil Biology and Biochemistry, 128, 139-149.

Fencing for Co-Management

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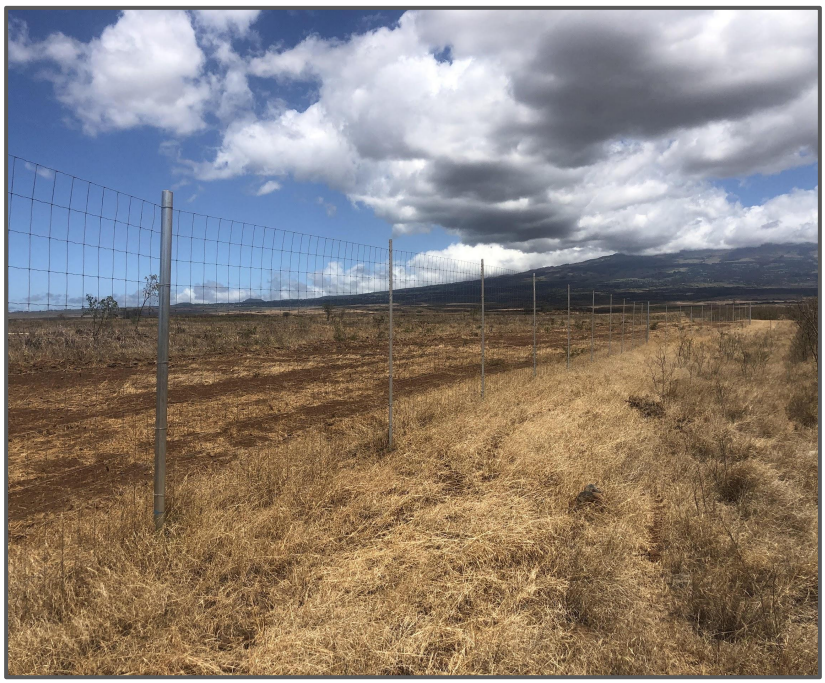
Fencing: A constructed barrier to animals or people.



Fencing used in central Maui to exclude invasive axis deer

How does fencing help?

Excludes wildlife which reduces the risk of feces and other contaminants from coming in contact with produce. Fencing reduces the ability of wildlife or livestock to transfer pathogens into a production zone.

Functions

- ➔ Wildlife exclusion
- ➔ Livestock enclosure

Best use: *Good for farms near forested areas or zones frequented by ungulates*

Benefits

...to food safety

- Reduced potential for animal fecal contamination in production zones

....to conservation

- Reduced soil disturbance from larger wildlife, critical to many native plants and ecosystems
- Improved water quality, as soil is at lower risk of erosion and hence reduced risk of sediment entering streams

Practicality

the pros

- Effective to eliminate damage from ungulates

the cons

- Expensive materials and installation
- State or federal restrictions regarding endangered species habitat may prevent installation

Literature Summary

- Electric fences reduced feral pig intrusions by 65% compared to non-electrical fences, with 2- and 3-strand fences having 40-50% fewer crossings than a single strand fence (Reidy et al. 2008).

- Hog wire panels were the most effective fencing option at containing feral swine, followed by woven-wire mesh and electric fences. Regular maintenance of hog panels and lethal removal by helicopter shooting further increased success to 97-100% (Lavelle et al. 2011).

References

Lavelle, M. J, Vercauteren, K. C., Hefley, Phillips, G. E., Hygnstrom, S., Long, D. B., Fischer, J. W., Swafford, S. R., and Campbell, T. A. 2011. Evaluation of Fences for Containing Feral Swine under Simulated Depopulation Conditions. USDA National Wildlife Research Center - Staff Publications. 1326.

Reidy, M. M., Campbell, T. A., and Hewitt, D. G. 2008. Evaluation of electric fencing to inhibit feral pig movements. The Journal of Wildlife Management, 72(4), 1012-1018.

Grassed Waterway for Co-Management

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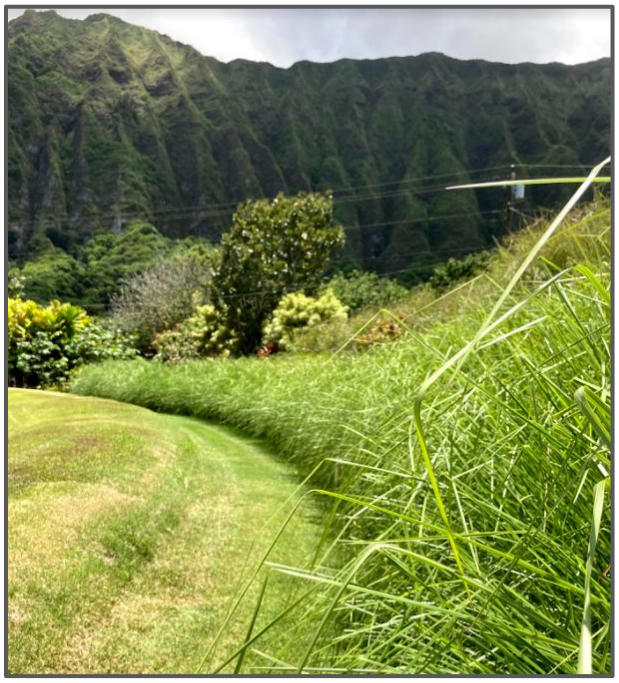
Grassed waterway: A vegetated channel that conveys surface water at a non-erosive velocity to a stable outlet.



A grassed waterway used to manage runoff in Waimanalo, Oahu

How does a grassed waterway help?

Encourages infiltration of potentially contaminated runoff into the soil and diverting away from production areas. This practice reduces the amount of potentially contaminated runoff that flows over production fields and reduces exposure of harmful pathogens on produce and/or to farm employees.

Functions

- ➔ Increased surface water infiltration
- ➔ Improved soil structure
- ➔ Increased plant cover

Best use: *Good for farms with steep topography and high rainfall*

Benefits

...to food safety

- Reduced risk of contamination from runoff and floodings to farm production areas

....to conservation

- Reduced soil erosion
- Building carbon and soil health
- Groundwater recharge

Practicality

the pros

- Helps to reduce problematic puddling
- Effective to guide water into more desirable areas, such as to a sediment basin/catchment pond

the cons

- Labor, equipment, and cost required to dig channel and establish seed.
- Requires regular manual maintenance of grass

Literature Summary

- Grassed waterways can significantly reduce runoff volume and velocity (up to 90% for unmanaged vs 10% for cut), including sediments and agrochemicals (Fiener & Auerswald, 2003).
- Peak discharge from a field can be reduced by a mean of 69% using grassed waterway installations. Sediment discharge at the catchment outlet decreased by a mean of 93% compared to the discharge measured in the grassed waterway's runoff inflow (Evrard et al., 2008)

References

Evrard, O., Vandaele, K., Van Wesemael, B., & Bielders, C. L. (2008). A grassed waterway and earthen dams to control muddy floods from a cultivated catchment of the Belgian loess belt. *Geomorphology*, 100(3-4), 419-428.

Fiener, P. and Auerswald, K. 2003. Effectiveness of grassed waterways in reducing runoff and sediment delivery from agricultural watersheds. Journal of Environmental Quality, 32(3), 927-936.

Mulching for Co-Management

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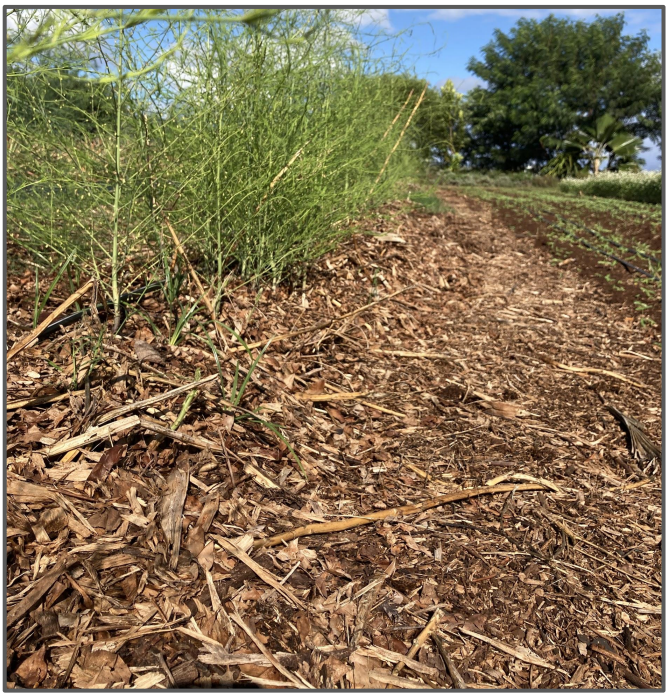
Mulching: Applying plant residues or other suitable materials to cover soil



Mulching used around asparagus in Waialua, Oahu

How does mulching help?

Mulching covers and protects the soil, which improves erosion control and soil health. Improves water infiltration into the soil, reduces the risk of potentially contaminated runoff or irrigated water coming in contact with produce. Additionally, mulch may create habitat for biodiverse organisms which may suppress pathogen populations.

Functions

- ➔ Increased microbial biodiversity
- ➔ Increased water holding capacity
- ➔ Increased soil cover
- ➔ Increased organic matter/ microbial substrate

Best use: *Good for farms that need to reduce irrigation costs and improve soil health*

Benefits

...to food safety

- Balancing/suppressing populations of human pathogens
- Reduced need for irrigation resulting in reduced risk of potentially contaminated runoff

....to conservation

- Building soil carbon and health
- Improved drought resistance
- Reduced erosion

Practicality

the pros

- Helps reduce soil movement and tracking around the farm
- Helps to reduce need for irrigation water, reduces water cost

the cons

- High cost and labor to implement
- Concern of creating habitat for undesired pests such as slugs and snails

Literature Summary

- Plastic mulch reduced *Salmonella* contamination on lettuce leaves in contaminated soils, likely due to reduced contact between lettuce and soil (Honjoh 2014).
- Green waste and organic mat mulches reduced windborne dust erosion by 60-80% compared to bare-ground at wind speeds less than 16 mph (Qu 2018).
- Bacteria and E.coli can survive under mulch, with higher populations found under plastic and straw mulch than bare ground (Micallef et al. 2016; Xu et al. 2016).

References

Honjoh, K. I., Mishima, T., Kido, N., Shimamoto, M., and Miyamoto, T. 2014. Investigation of routes of *Salmonella* contamination via soils and the use of mulch for contamination control during lettuce cultivation. Food Science and Technology Research, 20(5), 961-969.

Micallef, S. A., Callahan, M. T., and Pagadala, S. 2016. Occurrence and dispersal of indicator bacteria on cucumbers grown horizontally or vertically on various mulch types. Journal of food protection, 79(10), 1663-1672.

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Xu, A., Buchanan, R. L., and Micallef, S. A. 2016. Impact of mulches and growing season on indicator bacteria survival during lettuce cultivation. International Journal of Food Microbiology, 224, 28-39.

Vegetative Barrier for Co-Management

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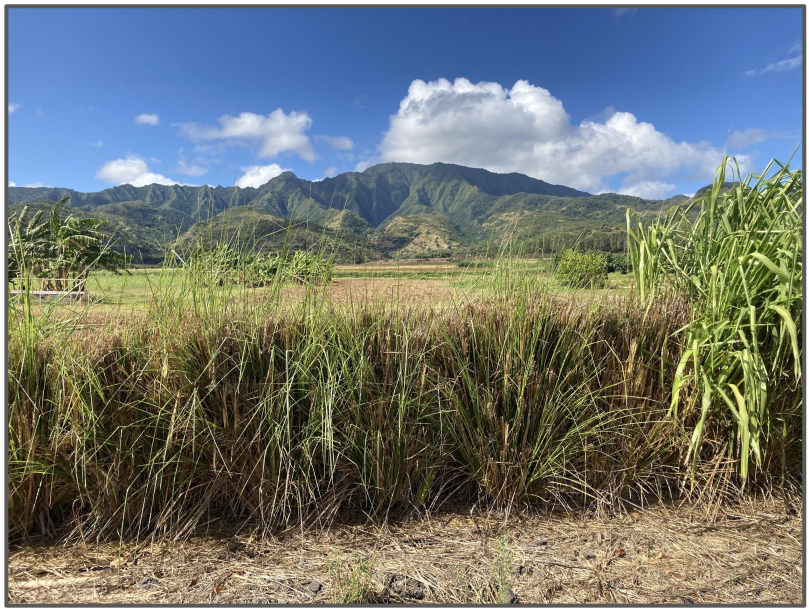
Vegetative barrier: Permanent strips of stiff, dense vegetation established across runoff areas, such as vetiver and ahuawa.



A vetiver installation at an organic farm in Waialua, Oahu

How does a vegetative barrier help?

Traps sediment and minimizes runoff containing potentially contaminated soil or water from entering active production areas, reducing exposure of harmful pathogens.

Functions

- ➔ Increased surface water filtration
- ➔ Increased living roots/plant cover
- ➔ Increased water infiltration

Best use: *Good for farms with steep topography and high rainfall*

Benefits

...to food safety

- Reduced transfer of potentially harmful pathogens via runoff and flooding into farm production areas

....to conservation

- Reduced soil erosion
- Building carbon and soil health
- Groundwater recharge

Practicality

the pros

- Effective to slow runoff and trap sediment in runoff

the cons

- Can create habitat for undesirable insects, birds, and rodents

Literature Summary

- Vegetated filter strips of fescue grass reduced runoff by 59-81% and fecal coliform discharge by 23-67% compared to bare-ground, primarily through increased water infiltration into the soil (Roodsari et al. 2005).
- Vegetated buffers from 1 to 25 meters wide reduced the fecal coliform levels in runoff water by more than 99% (Sullivan et al. 2007).
- Vegetative buffers reduced *E. coli* discharge by 0.3 to 3.1 $\log_{10}$ with each additional meter of buffer, but loss efficiency with higher runoff volumes (Tate et al. 2006).
- Hedgerows surrounding walnut orchards and tomato fields promoted wildlife diversity, but did not lead to increases in wildlife intrusion into crop production areas or prevalence of foodborne pathogens (Sellers et al. 2018).

References

Roodsari, R. M., Shelton, D. R., Shirmohammadi, A., Pachepsky, Y. A., Sadeghi, A. M., and Starr, J. L. 2005. Fecal coliform transport as affected by surface condition. Transactions of the ASAE, 48(3), 1055-1061.

Sellers, L. A., Long, R. F., Jay-Russell, M. T., Li, X., Atwill, E. R., Engeman, R. M., and Baldwin, R. A. 2018. Impact of field-edge habitat on mammalian wildlife abundance, distribution, and vectored foodborne pathogens in adjacent crops. Crop Protection, 108, 1-11.

Sullivan, T. J., Moore, J. A., Thomas, D. R., Mallery, E., Snyder, K. U., Wustenberg, M., Mackey, S.M. & Moore, D. L. 2007. Efficacy of vegetated buffers in preventing transport of fecal coliform bacteria from pasturelands. Environmental Management, 40(6), 958-965.

Tate, K. W., Atwill, E. R., Bartolome, J. W., and Nader, G. 2006. Significant *Escherichia coli* attenuation by vegetative buffers on annual grasslands. Journal of environmental quality, 35(3), 795-805.

Windbreaks for Co-Management

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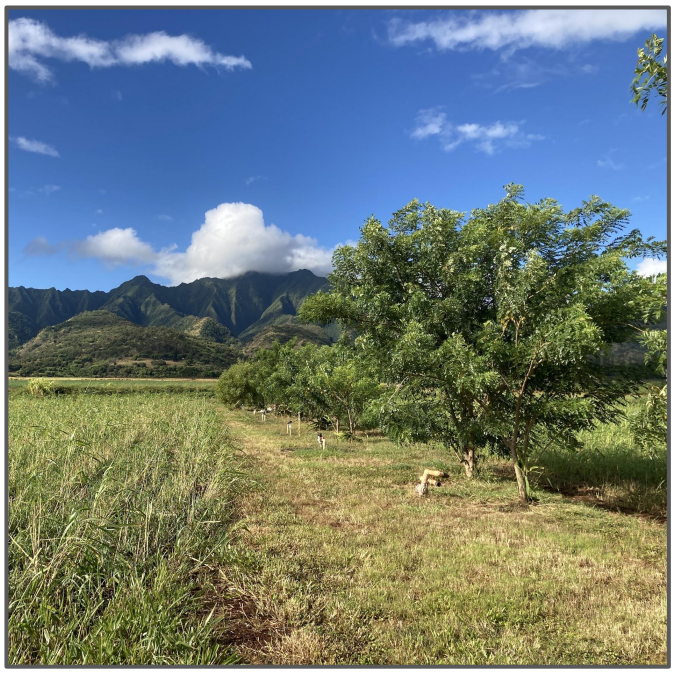
Windbreak: Single or multiple rows of trees or shrubs, positioned to reduce wind speed.



A gliricidia windbreak installed near production fields in Waialua, Oahu

How do windbreaks help?

Blocks wind and reduces airborne contamination risks. A windbreak installed perpendicular to the direction of prevailing winds can block undesired sediment and pathogens from landing on production fields and introducing risk from neighboring areas. Windbreaks may also decrease the rate of evaporation from production zones, resulting in a reduced need for irrigation and risk of irrigated water runoff.

Functions

- ➔ Increased plant biodiversity
- ➔ Interception of airborne pathogens
- ➔ Increased pollination
- ➔ Reduced evaporation of irrigated water

Best use: *Good for farms seeking visual or airborne contamination protection, or wind-sensitive crops*

Benefits

...to food safety

- Reduced transmission of airborne contaminants

....to conservation

- Build soil health and carbon, habitat creation
- Water conservation
- Reduce wind erosion

Practicality

the pros

- Reduces wind stress on crop
- Reduces pesticides/herbicide drift and sediment transport from neighbor operations
- May be multi-purpose, such as food/timber

the cons

- Length of land lease may impact farmer desire to invest in permanent vegetation
- Can encourage undesired bird populations near fields

Literature Summary

- Vegetative tree buffers of cypress, willow, pine, or cedar reduced dust in the air downwind of the buffer strip by 30%-60% of dust (Malone 2004; Hernandez 2012).

- Vegetative tree buffers of maple, oak, poplar, adler, willow, and grasses reduced viral infections of chicken coops compared to the control in only the last year of a 3-year study. It was thought that once the buffers had grown to a fuller and greater height, they would have functioned better to reduce the spread of pathogens (Burley et al. 2011; Sames et al. 2020).

References

Burley, H. K., Adrizal, A., Patterson, P. H., Hulet, R. M., Lu, H., Bates, R. M., Martin, G. P., Myers, C. A. B. and Atkins, H. M. 2011. The potential of vegetative buffers to reduce dust and respiratory virus transmission from commercial poultry farms. Journal of Applied Poultry Research, 20(2), 210-222.

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Malone, B. 2004. Using trees to reduce dust and odour emissions from poultry farms. Proc. Poult. Information Exchange, 33-38.

Sames, A., Noll, S., Wyatt, G. J., Zamora, D., Current, D., & Janni, K. 2020. Effects of Vegetative Windbreaks on Dispersal of Highly Pathogenic Avian Influenza-A Review of Literature. Journal of the NACAA, 13(1).

Resources

1. Learn more about co-management: Wild Farm Alliance: Food safety and Conservation Resources
2. Learn more about food safety: Roots FSMA Guide & Produce Safety Alliance
3. Learn more about conservation practices and on-farm assistance opportunities: Oahu RC&D & CTAHR Extension

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