

GLOSSARY OF TERMS FOR BIODEGRADABLE MULCHES FOR SPECIALTY CROPS PRODUCED UNDER HIGH TUNNELS

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1. **Biodegradable:** Capable of being broken down via microbial activity, as opposed to degradable, which refers to materials that can be broken down by abiotic factors such as heat, UV light, or mechanical stress. Complete biodegradation (i.e., mineralization) refers to the oxidation of the parent compound (an organic molecule) to carbon dioxide and water. Biodegradation provides both carbon and energy for the growth and reproduction of cells.
2. **Biodegradable mulch (other):** Whole plant, plant debris, or plant product such as cover crops, straw, tree bark, wood chips, or paper, that is used for weed control and moisture conservation. Often tends to reduce soil temperatures. Will biodegrade in the soil due to microbial activity.
3. **Biodegradable plastic mulch:** Manufactured alternative to plastic mulch. Ideally, biodegradable mulch provides the same benefits as plastic mulch (weed control, soil temperature moderation, reduced soil-borne pathogens, soil moisture retention, and soil conservation) and provides the added benefit of being 100% biodegradable, either in the field, soil or in composting, with no formation of toxic residues.
4. **Biofumigation:** Elimination or suppression of plant pathogens, nematodes or weeds in the soil by amendment with biological products, particularly *Brassica* plants or seed meals. These produce isothiocyanates as they break down, and appear to directly suppress some pests. They may also act indirectly on the pests by favoring the growth of organisms antagonistic to the pathogens.

5. **Biomass:** The total mass of all organisms in a given population or geographical area; usually expressed as total dry weight.
6. **Clean technology:** A means of rendering goods or services that exhibit similar or better level of functionality, measurably superior environmental performance, at comparable long-run economic costs as that of those goods/services rendered by conventional technology.
7. **Cold frame:** A small structure, usually low, rectangular, unheated, and often portable, used for starting plants or hardening transplants. Traditionally constructed from wood. In the nursery industry “cold frame” is used to describe a hoop house structure (see High Tunnel).
8. **Composting** (agricultural sense): The process ‘to compost’ is the biological decomposition of organic materials by microorganisms under controlled, aerobic conditions to produce a relatively stable humus-like material called ‘compost’. For agricultural operations the common materials or feedstocks that are composted are livestock manures, livestock bedding, and various residual plant materials (straw, culls, on-farm processing wastes, etc). Composting is much more than just allowing manure to pile up and decompose until ready for use—it is a science. The decomposition occurs in a well-managed process to obtain specific positive results—a valuable product—with a minimum of negative environmental impacts.
9. **Composting** (materials sense): A managed process that controls the biological decomposition and transformation of biodegradable materials into a humus-like substance called compost: the aerobic mesophilic and thermophilic degradation of organic matter to make compost; the transformation of biologically decomposable material through a controlled process of bio-oxidation that proceed through mesophilic and thermophilic phases and results in the production of carbon dioxide, water, minerals, and stabilized organic matter. (compost or humus).
10. **Crop covers:** Also called row covers. Flexible, transparent or semi-transparent materials used to cover and protect crops from cold, wind, and insect damage. Two main types of material commercially used are polyethylene (clear) and porous, floating, nonwoven polyester or polypropylene. Examples of trademark manufacturers include *Reemay*, *DuPont*, *Kenbar*, *Polymax*, *Starfoam*.
11. **Degrade:** Measurable conversion or mineralization of C to CO₂. Different than ‘deterioration’ – see definition below.
12. **Degradable polymeric material** (or “plastic”): “designed to undergo a significant change in its chemical structure under specific environmental conditions resulting in a

loss of some properties that may vary as measured by standard test methods appropriate to the polymeric material and the application in a period of time that determines its classification.”

13. **Deterioration:** Loss of physical or mechanical strength, as observed through physical strength testing, microscopic imaging, or sizable macroscopic alteration of morphology (e.g. rips, tears, and holes assessed visually). Different than ‘degradation’ – see definition above.
14. **‘End’ products:** Final output of an activity, arrangement, or process. Articles, materials, and supplies delivered (or are to be delivered) under a contract.
15. **Environmental burden:** The total set of resources used, emissions and residues during the life cycle of a product or an item.
16. **Extrusion:** A process by which a heated polymer is forced through an orifice to form a molten stream that is cooled to form a filament or fiber. A solution of the polymer can also be forced through the orifice into a solvent that causes the fiber to solidify.
17. **Extruder:** An apparatus for extrusion.
18. **Fabric:** A sheet structure made from fibers, filaments or yarns.
19. **Field tunnels:** See Low Tunnels and High Tunnels
20. **Floating row covers:** Floating row covers are made of spun-bonded polyester and spun-bonded polypropylene and are so lightweight that they "float" over most crops without support. (Crops with tender, exposed growing points, such as tomatoes and peppers, are exceptions. To prevent damage from wind abrasion, the cover should be supported with wire hoops.) The spun-bonded fabric is permeable to sunlight, water, and air, and provides a microclimate similar to the interior of a greenhouse. Plants are protected from drying winds by what amounts to a horizontal windbreak, and the covers give 2 to 8°F of frost protection. In addition to season extension, advantages include greater yields, higher-quality produce, and exclusion of insect pests.
21. **Greenhouse, heated:** Permanent structure, usually with concrete foundations or footings, covered with glass or plastic; equipped with heating, lighting and ventilation systems; may include irrigation; may be partly or entirely automated.
22. **Greenhouse, unheated:** [Unheated greenhouse] is one in which it is neither convenient nor desirable to have a fixed heating apparatus.

23. **Gutter connection:** A gutter-connected greenhouse is a series of trusses connected together at the gutter level. Individual bays vary in width from 12' to 25' and have a clearance of 8' to 16' to the gutter. Bays can be put together to get any width of greenhouse desired.
24. **Haygrove:** A trade name high tunnel, based in England; made from steel hoops that are designed as either a single unit (solo) or gutter-connected multi-bays. Relatively low-cost tunnels, best in sheltered sites where crops need low-cost protection during spring, summer and early fall. Can be 24 to 36 feet wide and 200 feet or more long.
25. **High tunnel:** A temporary agricultural structure with arched or hoop-shaped frames covered with one or more layers of clear plastic. They are high enough to drive a tractor through. Crops are grown in the ground, usually with drip irrigation. Most high tunnels are solar heated, using no electricity. They can be easily covered and uncovered, and easily assembled and disassembled in order to move to a different field site. High tunnels have a positive impact on season extension.
26. **Hoop house:** Three or 4-season high tunnel, usually built more securely along sides and ends to withstand inclement weather such as snow and heavy winds.
27. **Impact:** The social, economic, civic, and/or environmental consequences of an educational program. Impacts tend to be longer-term and so may be equated with goals. Impacts may be positive, negative, and/or neutral and intended or unintended.
28. **Life cycle assessment:** The method/process for evaluating the effects that a product has on the environment over the entire period of its life from 'cradle to grave', thereby increasing resource use efficiency and decreasing liabilities.
29. **Low tunnels:** Sometimes called a cloche. Essentially a structure of row covers supported on wire hoops, placed over crop rows in the field consisting of either plastic film with vent holes or slits, or row cover material placed over No. 9 wire bent in a half circle, or plastic hoops; usually have a peak height of 18" to 36" from the soil surface. Cover is secured on both sides and ends with soil or heavy objects (rocks, wood, concrete blocks), or to the hoops with clips.
30. **Mulch:** (verb) Application of a covering (bulk, film or fabric) to the soil surface of a row of plants. (noun) Any product so applied. Common mulches include straw, sawdust and polyethylene film. Mulches are most commonly used to control weeds, but can also modify soil temperature and can reduce water loss due to evaporation from the soil surface. Film mulches are commonly used in solarization, fumigation and biofumigation.

31. **Nonwoven fabric:** A fabric made directly from a web of fiber, without the yarn preparation necessary for weaving and knitting. In a nonwoven, the assembly of textile fibers is held together 1) by mechanical interlocking in a random web or mat; 2) by fusing of the fibers, as in the case of thermoplastic fibers; or 3) by bonding with a cementing medium such as starch, casein, rubber latex, a cellulose derivative or synthetic resin. Initially, the fibers may be oriented in one direction or may be deposited in a random manner. This web or sheet is then bonded together by one of the methods described above. Fiber lengths can range from 0.25 inch to 6 inches for crimped fibers up to continuous filament in spunbonded fabrics. Nonwoven fabrics are currently used as weed mats, and row covers.
32. **Organic standards:** A federal program managed by USDA, the National Organic Program (NOP) has standards which producers must meet in order to be certified as organic. Standards include inputs and techniques that are allowable and not allowable. An overview of being certified organic includes: avoidance of prohibited synthetic chemical inputs (e.g. fertilizers, pesticides, antibiotics, food additives, etc), genetically modified organisms, irradiation, and the use of sewage sludge; use of farmland that has been free from chemicals for three or more years; keeping detailed written production and sales records (audit trail); maintaining strict physical separation of organic products from non-certified products; and undergoing periodic on-site inspections.
33. **Outcomes:** Results or changes that occur from an educational effort. Outcomes may relate to changes in knowledge, awareness, skills, attitudes, opinions, aspirations, motivation, behavior, practice, decision-making, policies, social action, condition or status. Outcomes may be intended and unintended; positive and negative. Outcomes fall along a continuum from immediate (initial; short-term) to intermediate (medium-term) to final outcomes (long-term), often synonymous with impacts.
34. **Paper mulch:** Primarily used for weed control, soil moisture conservation, and soil erosion control. Tends to reduce soil temperature and is short lasting (3-4 months). Products vary from 32-40-pound kraft paper, may be dyed black, unbleached, or undyed 100% recycled kraft paper. Papers may be treated with natural substances such as vegetable oil (soybean) and elemental sulfur. Offers many of the advantages of plastic mulches, but does not require disposal as it is biodegradable and can be tilled into the soil after harvest. Comes on rolls, generally 36 – 48 inches wide and up to 1500 feet long; covers the soil in a bed or row. Trade name products include ‘Planters Paper’ and ‘Weed Guard’.
35. **Passive solar:** Using sunlight for useful energy without use of active mechanical systems. Such technologies convert sunlight into usable heat (water, air, thermal mass), cause air-movement for ventilating, or store heat for future use, with little use of other

energy sources. Passive solar systems have little to no operating costs, often have low maintenance costs, and emit no greenhouse gases in operation.

36. **PET:** Polyethylene terephthalate (sometimes written poly(ethylene terephthalate)), is a thermoplastic polymer resin of the polyester family (derived from petroleum feedstock DGH) and is used in synthetic fibers; beverage, food and other liquid containers; thermoforming applications; and engineering resins often in combination with glass fiber. It is one of the most important raw materials used in man-made fibers.
37. **PLA:** [poly(lactic acid)], a more general classification vs PLLA [poly(L-lactic acid)] vs PDLA [poly(D-lactic acid)] vs PDLLA [poly(D,L-lactic acid) where polymers contain mixtures of D- and L- monomeric units). Differentiation is related to chiral carbon that occurs in lactic acid monomeric unit. Lactic acid produced by most organisms is primarily in the L-enantiomeric form.
38. **Plastic film:** A thin sheet of plastic material, sometimes transparent, used to wrap or cover things.
39. **Plastic mulch:** A thin plastic sheet usually 0.6 – 1.5 mm in thickness, available as 36 – 52 inches wide rolls, up to 6000 feet long and used to cover the soil in a bed or row primarily for weed control. Often used in conjunction with drip irrigation and crops grow through slits or holes in the plastic sheet. Impacts soil temperatures and conserves moisture from irrigation; available in various colors and weights. Disposal of the plastic mulch after use is an issue in most areas where it is used.
40. **Powdery mildew:** Fungus (or disease) that forms a superficial white coating on the surface of leaves, stems, fruits, buds, and flowers; generally refers to members of the Erysiphales or a type of disease caused by these fungi. Powdery mildew diseases are generally favored by high humidity rather than free moisture.
41. **Quonset huts:** Buildings with a semicircular cross-section, sturdier than straight wall buildings, less costly to buy and assemble.
42. **Recycling:** A resource recovery method involving the collection and treatment of waste products for use as raw material in the manufacture of same or similar product.
43. **Renewable resources:** Resources capable of being continuously renewed or replaced through such processes as organic reproduction and cultivation such as those practiced in agriculture, animal husbandry, forestry and fisheries.
44. **Ridge vents:** A vent installed at the peak of a sloped or peaked roof to let warm, humid air escape.

45. **Row covers:** See crop covers. Flexible, translucent coverings made from polyester or polypropylene that are installed over single or multiple rows of horticultural crops in the field or high tunnel for the purpose of enhancing plant growth by warming the air around the plants, or to protect plants from insect pests (sometimes referred to as insect barrier). Floating row covers lie directly over the crops; several rows or a field may be covered by one unit.
46. ***Sclerotinia sclerotiorum*:** A fungus that causes white mold on plant stems and crowns on a wide variety of hosts, especially vegetables, and can survive in the soil for many years in overwintering structures called sclerotia.
47. **Smart materials:** Materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, pH, electric or magnetic fields.
48. **Solarization:** Elimination or suppression of plant pathogens, nematodes or weeds in the soil by solar heating. The soil is brought up to a moist, workable condition (typically about 70% of field capacity) and is worked to a fine texture. Clear film is laid tightly over the soil, and remains in place for several weeks to several months. The practice is most effective under hot, sunny conditions.
49. **Specialty crops:** Fruits and vegetables, tree nuts, dried fruits, and horticulture and nursery crops including floriculture.
50. **Spunbond(ed):** The filaments have been extruded, drawn and laid on a moving screen to form a web. The term is often interchanged with “spunlaid,” but the industry conventionally adopted the spunbond or spunbonded term to denote a specific web forming process. This is to differentiate this web forming process from the other two forms of the spunlaid web forming, which are melt blown and flashspinning.
51. **ASTM D6400:** Standard specification for compostable plastics,
- For “...plastics that are designed to be composted in municipal and industrial aerobic composting facilities”
 - For “establish the requirements for labeling ...as “compostable in municipal and industrial composting facilities”
 - Degradable plastic: “...designed to undergo a significant change in its chemical structure under specific environmental conditions, resulting in a loss of some properties that may be measured by standard test methods”

- BD Plastic: “a degradable plastic in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi, and algae.”
- Requirement 1: Loss of 90% dry mass of plastic under composting during 12 weeks (D5338)
- Requirement 2: (“inherent biodegradation”) 60% of C atoms converted to CO₂ in 180 days (compared to control) for single polymers (for blends, 60 or 90% conversion in 12 wk, depending on the nature of the blend).

52. **Standard for biodegradation** of plastics in soil

- Does not exist in ASTM
- Standards exist in Italy?, Norway?. .. Mark Williams of BioBag, Inc, will provide us in the near future
- An EU standard; an ASTM (and ISO?) standard may be developed in the near future. Dr. Ramani Narayan may play a role in establishing the ASTM standard (“X% of C atoms in plastic converted into CO₂ during Y months of exposure to soil at a specified set of conditions...”)
- ASTM D5988, or a modified version thereof, may be used for the testing. Key concept: Biodegradation in the soil may be specified to be several months. The ASTM testing protocol will need to show results in an accelerated time period. Perhaps a long-term goal will be to show that results from a modified version of D5988, using “cherry-picked” conditions to accelerate the rate of biodegradation,” is proportional to the actual long-term biodegradation exhibited in soil tests: greenhouse studies as per Activity II-A? High Tunnel or Field Studies as per Activity III?

53. **ASTM D5988-3**: Standard test method for determining aerobic biodegradation in soil of plastic materials or residual plastic materials after composting,

- Requires selection of a common microbe and soil type. Soil water activity, pH, etc., controlled.
- Operated via a dessicator.
- Biodegradation assessed by comparison to a positive control.
- CO₂ measured via reaction with Ba(OH)₂ yielding BaCO₃; reactant Ba(OH)₂ concentration determined via titration.

- Biodegradation process can also be monitored through BOD (biological oxygen demand).
- There will be 3 replicates per sample. For each set of expts, a positive control and a blank will need to be performed. For example, if 2 BDMs are to be tested, $3 \times 3 + 2 = 11$ samples will need to be monitored. There is no need to include a negative control. (R. Narayan)
- Equipment assessment: dessicators will need to be used for each run. Therefore, to test 2 BDM samples, 11 dessicators will need to be obtained. Perhaps other glassware can be substituted for the dessicators (D. Hayes).
- Can require several weeks of monitoring.

54. **ASTM D 5338-98:** Standard test method for determining aerobic biodegradation of plastic materials under controlled composting conditions,

- Similar to D5988, except:
- A specified compositing apparatus is required:
- 2 L reactors with aerators
- A robust means of measuring CO₂, such as IR, should be considered
- Positive and negative controls are used

55. **Sustainable material:** Materials from renewable sources that can be produced at high volumes without adversely affecting the environment or critical ecologies.

56. **Renewable Materials:** Renewable raw materials comprise the totality of plant, animal and microbial biomass, including biomass delivered through food chains, whose primary production is based on photosynthesis and which are provided for material and energy uses of all kinds outside food and feed. With material use, the biomass serves as raw material for the (industrial) production of all types of goods.

57. **Green Chemistry:** Green chemistry, also known as sustainable chemistry, is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, and use.

58. **Sustainable Development:** To meet the needs of the present without compromising the ability of future generations to meet their own needs.

59. **Biobased Plastics:** High polymeric materials obtained from raw materials that can be obtained through chemical or biological synthesis from raw materials that confer substance derived from renewable resources.
60. **Biobased:** Commercial or industrial products (other than food or feed) that are composed in whole or in significant part of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials.

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