

Compost Standards and Quality

Greg Evanylo

Professor and Extension Specialist

gevanylo@vt.edu

Confined Animal Manure Managers Workshop

January 16, 2020

Why test compost?

- Assess the process
- Regulatory requirement
 - Environment, health & safety
- Customers want/need results
 - Avoid problems
 - Meet specifications



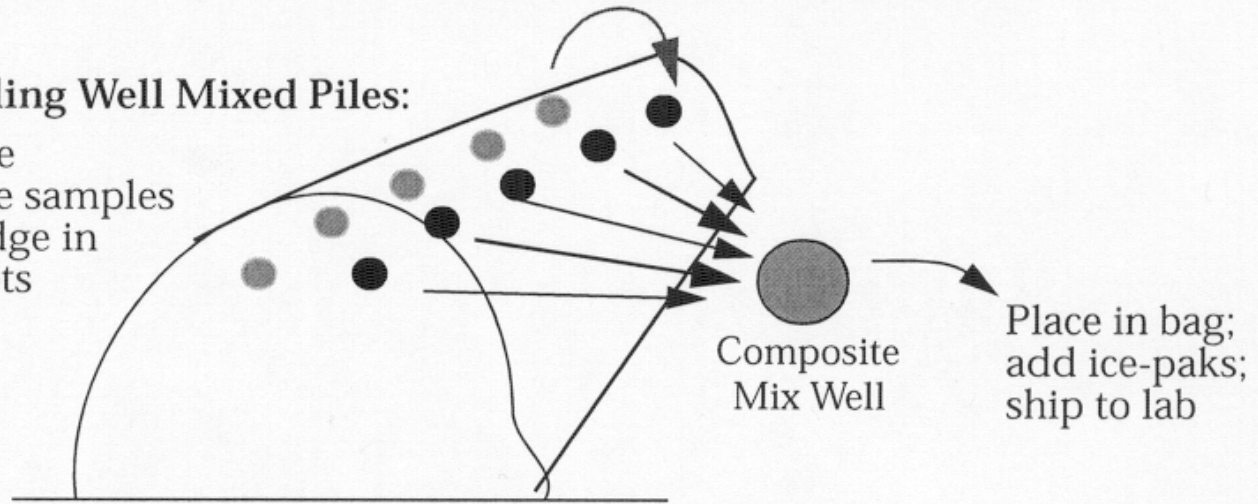
Compost quality should be defined by its intended use



A compost good for one use may be bad for another

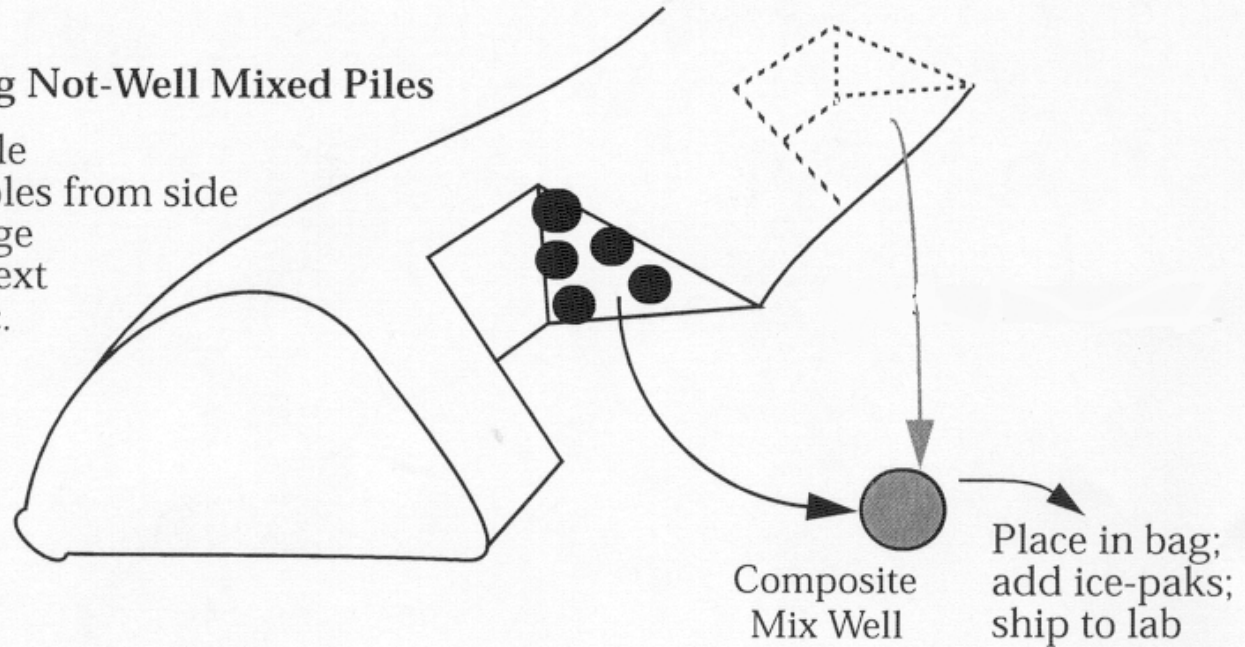
A. Sampling Well Mixed Piles:

- Mix pile
- Remove samples along edge in 5-10 spots



B. Sampling Not-Well Mixed Piles

- Cut into pile
- Take samples from side exposed edge
- Cut into next location, etc.



Compost Quality Standards Developed by Composting Industry

- U.S. Composting Council
(<http://compostingcouncil.org/index.cfm>)
 - Test Methods for the Examination of Composting and Compost (TMECC) laboratory manual
 - Seal of Testing Assurance (STA)
- Seals of Approval
 - Woods End Research Laboratory
(<http://www.woodsend.org/>)
 - California Compost Quality Council
(<http://www.crra.com/ccqc/ccqchome.htm>)

Physical Properties of Compost

Property	Common units	Significance
Moisture content	%	Spreadability, dustiness
Bulk density	lbs/cu yd	Indicator of porosity
Water holding capacity	%	Indicator of water supplying capability
Particle size distribution	% passing sieves	Contributes to porosity and WHC

Chemical Properties of Compost

Property	Units	Significance
Total Organic C	%	Calculate C:N
Volatile solids	%	Indicator of OM
Cation Exchange Capacity, CEC	meq/100g, cmol(+)/kg	Cation holding capacity
N – all forms	%, ppm	Total and available N
pH		Indicator of acidity/alkalinity
Electrical Conductivity, EC	mmhos/cm, dS/m	Measure of soluble salts
P, K, Ca, S, etc.	%, ppm	Nutrient availability

Biological Properties

Pathogenic and beneficial microbes



- Pathogens
 - Fecal coliforms and Salmonella as indicators of safe compost
- Beneficial at frontier of science
 - Pathogen antagonists
 - Plant biostimulants
- Specialty testing labs
 - Soil Food Web



**US COMPOSTING
COUNCIL**

*Seal of Testing
Assurance*

Barnes – Regional Composting
3511 West Cleveland Ave.
Huron, OH 44839
Telephone: 800-421-8722
Fax: 419-433-3555

Sample Date: 8/14/02

COMPOST TECHNICAL DATA SHEET

Compost Parameters	Reported as (units of measure)	Test Results	Test Results
<i>Plant Nutrients:</i>	%, weight basis	%, wet weight basis	%, dry weight basis
Nitrogen	Total N (TN or TKN+NO ₃ -N)	.72	1.12
Phosphorus	P ₂ O ₅	.13	.21
Potassium	K ₂ O	.32	.50
Calcium	Ca	2.34	3.64
Magnesium	Mg	.57	.89
Moisture Content	%, wet weight basis	42	
Organic Matter Content	%, dry weight basis	31.31	
pH	unitless	7.4	
Soluble Salts <i>(electrical conductivity)</i>	dS/m (mmhos/cm)	3.49	
Particle Size	screen size passing through	½"	
Stability Indicator <i>(respirometry)</i> CO ₂ Evolution	mg CO ₂ -C/g TS/day, AND	.14	
	mg CO ₂ -C/g OM/day	.5	
Maturity Indicator <i>(bioassay)</i> Percent Emergence, AND Relative Seedling Vigor	average % of control, AND	92	
	average % of control	86	
Select Pathogens	PASS/FAIL: per US EPA Class A standard, 40 CFR § 503.32(a)	Pass	
Trace Metals	PASS/FAIL: per US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3.	Pass	

Participants in the US Composting Council's Seal of Testing Assurance Program have shown the commitment to test their compost products on a prescribed basis and provide this data, along with compost end use instructions, as a means to better serve the needs of their compost customers.

Directions for Product Use:

New Lawns: Apply a 1-2" layer to soil and incorporate to a depth of 5-7", apply seed, then rake and water.

Flower Beds: Apply a 1-2" layer to soil and incorporate to a 6-8" depth. Condition soil this way every year to 2 years. Plant flowers and water.

Trees & Shrubs: Dig a hole 2/3 the depth of the root ball and at least twice as wide. Mix 1 part compost with 2 parts soil obtained from the planting hole. Place the tree or shrub in the planting hole and apply amended soil around the root ball. Firm soil occasionally and water.

Topsoil Manufacturing/Upgrading: Mix 1 part compost with 2 parts existing or purchased soil and blend uniformly.

Growing Mixes: Planter box or raised bed mixes can be produced by mixing 1 part compost to 1 part pine bark and 1 part soil, sand or expanded shale. Potting mixes should contain 1 part compost, 1 part peat moss or pine bark, and 1 part perlite, vermiculite, styrofoam, or other aggregate.

Mulching: Spread a 2-3" layer around trees, shrubs, and flowers. Always avoid placing mulches against plant trunks and stems.

Garden Beds (food crops): Apply a 1-2" layer to soil and till to a 6-8" depth. Reapply each year, or as per soil test recommendations.

NOTE: The USCC does not assess whether or not, or to what extent, these directions are sound, sufficient or otherwise appropriate. It is the participant's responsibility alone to ensure that they are.

Compost Ingredients:

Yard trimming, food by-products

This compost product has been sampled and tested as required by the Seal of Testing Assurance Program of the United States Composting Council (USCC), using certain methods from the "Test Methods for the Examination of Compost and Composting" manual. Test results are available upon request by calling Barnes Nursery at 800-421-8722. The USCC makes no warranties regarding this product or its contents, quality, or suitability for any particular use.

For additional information pertaining to compost use, the specific compost parameters tested for within the Seal of Testing Assurance Program, or the program in general, log on to the US Composting Council's TMECC web-site at <http://www.tmecc.org>.

Compost Property Values

Variable	Typical	Preferred
pH	5.0-8.5	6.0-7.5
EC (dS/m)	1.0-10	< 4.0
Organic matter (%)	30-70	> 50
Water holding cap (%)	75-200	> 100
Moisture content (%)	30-70	40-50
Bulk density (lbs/cy)	700-1200	800-1000

Compost Property Values

Variable	Comments
Nutrients	No minimum; list concentrations
Particle size	Dependent on use
Trace elements	USEPA 40 CFR Part 503 Rule
Stability	Stable to highly stable
Phytotoxicity	Must pass seed germination & plant growth assays

Compost Maturity

- Stability
 - The degree of decomposition of energy-containing feedstock used by microbes
- Fitness for use (e.g., phytotoxicity)
 - Immature composts can be phytotoxic
 - Free ammonia
 - Volatile organic acids

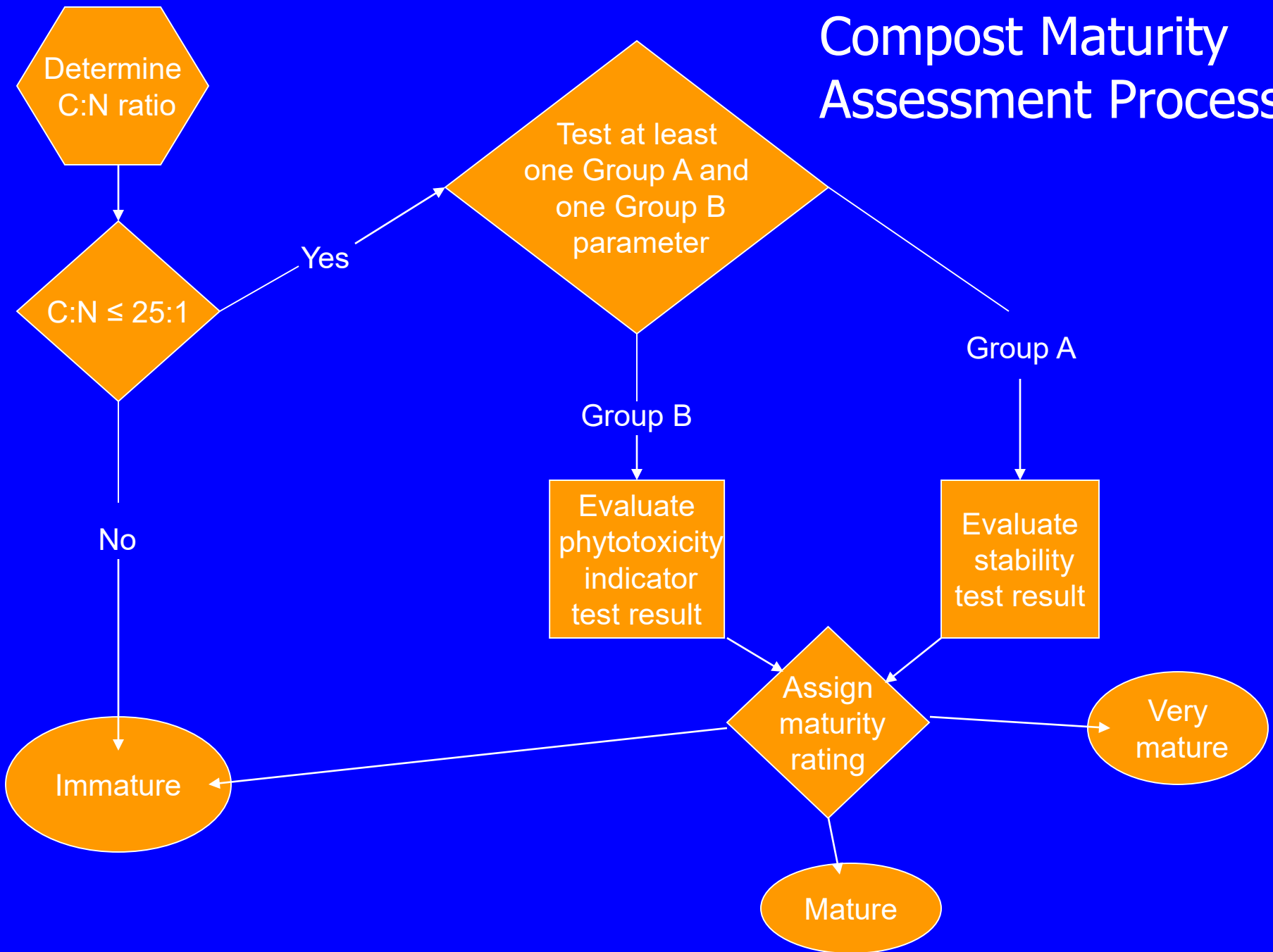
Fermentation-induced
phytotoxicity caused
mostly by acetic acid in
composted mulch



Compost Maturity Index

Very mature	Mature	Immature
Well cured compost	Cured compost	Uncured or raw compost
No continued decomposition	Odor production not likely	Odor production likely
No toxicity potential	Low toxicity potential	High toxicity potential
No impact on available soil N	Low impact on available soil N	High impact on available soil N

Compost Maturity Assessment Process



Compost Maturity Index Parameters

Group A (stability)	Group B (phytotoxicity)
<p>Respirometry tests:</p> <ul style="list-style-type: none">┆ Specific O₂ uptake rate (SOUR)┆ CO₂ evolution┆ Dewar self-heating test┆ Solvita CO₂	<p>Ammonium (NH₄)</p> <p>NH₄-N:NO₃-N</p> <p>Solvita NH₃</p> <p>Volatile fatty acids (VFAs)</p> <p>Biological assays:</p> <ul style="list-style-type: none">┆ Emergence & seedling vigor┆ In vitro germination and seedling elongation

Assessing Stability



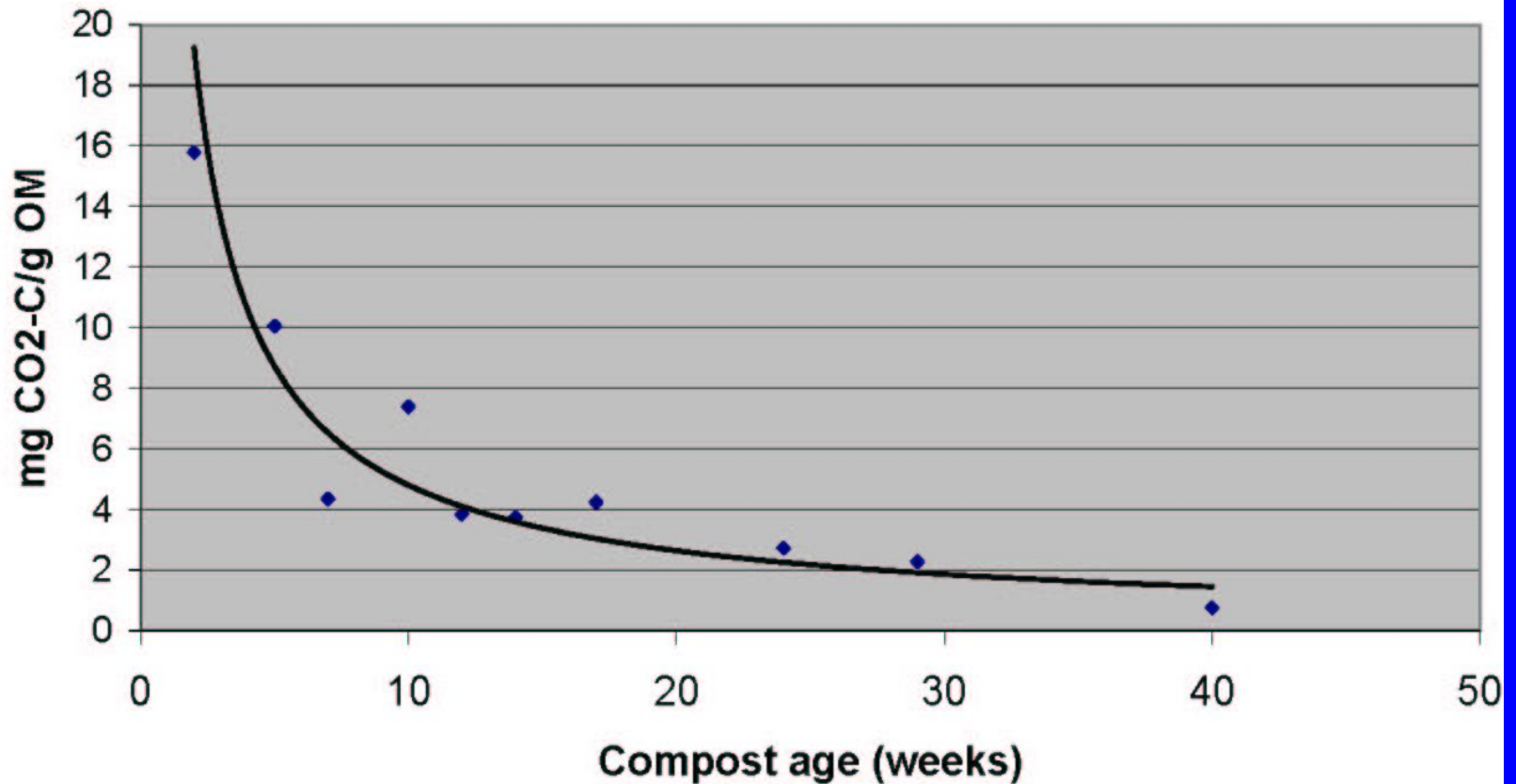
Respirometry



Self-heating

TMECC method:CO₂ Evolution

STABILITY TEST:
CO₂ Evolution vs Compost age



Respirometry Stability Classes

Group A (stability)	Rating		
	V. stable	Stable	Unstable
SOUR (mg O ₂ /g OM/d)	<3	3-10	>10
CO ₂ evolution rate (mg CO ₂ -C/g OM/d)	<2	2-4	>4
Dewar self-heating test (Dewar index)	V		<V
Headspace CO ₂ (color code for Solvita CO ₂)	7-8	5-6	1-4

Assessing Maturity: Solvita Quick Test



SOLVITA
BY WOODS END® RESEARCH
P.O. Box 297 • Mt. Vernon, ME 04352

**COMPOST MATURITY
CARBON - DIOXIDE TEST**
(paddle "C")
- please see instructions for use -

Control Color ↓

Low CO₂ High CO₂

8 7 6 5 4 3 2 1

SOLVITA
BY WOODS END® RESEARCH
P.O. Box 297 • Mt. Vernon, ME 04352

**COMPOST MATURITY
AMMONIA TEST**
(paddle "A")
- please see instructions for use -

Control Color ↓

Low Ammonia High Ammonia

5 4 3 2 1

Cress (*Lepidium sativa*) Test

Approved by: Swiss Compost Association, German Compost Association, and Woods End Laboratory & Rodale Quality Seal.

Most widely recognized plant species for compost bioassays:

- moderately sensitive to salinity
- insensitive to auxinic herbicides



Control (Pro-Mix)

Compost

Cucumber Test (USCC TMECC)

Not a compost maturity indicator:

- fungal pathogens
- soluble nitrogen (ammonia + nitrate)

Control
(Pro-Mix)



Compost

Top Growth Study

Growth Series: 0-20-40-80-100% manure compost with soybeans, which are sensitive to salt stress, trace element toxicity and auxinic herbicides.



Compost had 8 dS/M (mmhos/cm) conductivity which limits its use to 15-20% addition.

Root Growth Study

Growth Series: 0-25-50-100% MSW compost with sorghum-sudangrass. 21 day trial.



Root inhibition from moderately immature (high VFA content) compost with elevated soluble salts level began after 25%.

Phytotoxicity Thresholds

Group B (Phytotoxicity)	Phytotoxicity Rating		
	None	Low	High
NH ₄ (mg/kg dw)	<75	75-500	>500
NH ₄ -N:NO ₃ -N	<0.5	0.5-3.0	>3.0
Seedling emergence & vigor (% of control)	>90 & >95	80-90 & 85-95	<80 & <85
In vitro germ. and root elongation (% of control)	>90	80-90	<80
NH ₃ (Solvita NH ₃ color code)	5	4	1-3
VFAs (mmoles/g dw)	<200	200-1000	>1000

Maturity Assessment Matrix

		Group B Outcome (phytotoxicity rating)		
		None	Low	High
Group A Outcome (stability rating)	V. Stable	Very mature	Mature	Immature
	Stable	Mature	Mature	Immature
	Less stable	Immature	Immature	Immature

Herbicide Residues in Compost

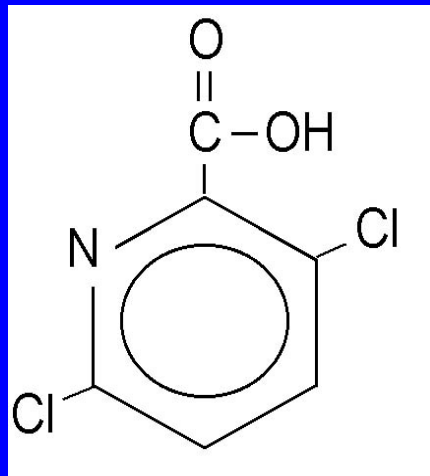
- Phytotoxicities, 2000-2002
 - Tomatoes (Spokane, WA)
 - Vegetables (Washington State U)
 - Vegetables (Penn State)



- Traced to compost produced from yard trimmings, livestock manure & bedding

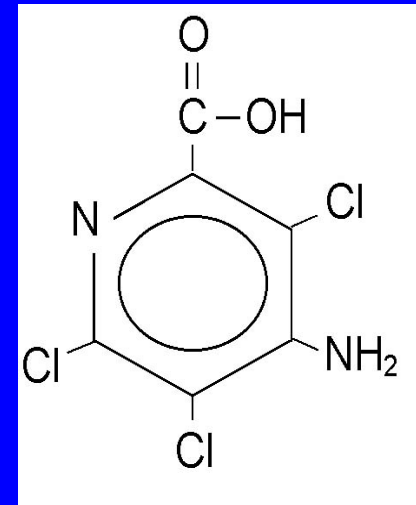
Properties of Clopyralid & Picloram

- Pyridine carboxylic acids
- Mimic plant growth regulators (auxins)
- Very water soluble
- Effective at low conc's (<10 ppb soil)



Clopyralid

Picloram



Herbicide Residue Bioassays



Detail: Leaf curl in red clover (*Trifolium pratense*) at low herbicide levels.

Red clover is sensitive in the range 3-50 ppb, but soluble salts may interfere with interpretation.

Weed seeds



- Measured with germination test
- What do weeds indicate?

Inert Contaminants

Metal, glass, plastic fragments

- Metals: Potential for physical injury
 - Sources: trash, demolition materials
- Glass: Potential for physical injury
 - Sources: trash, demolition materials
- Plastic: Aesthetics
- Total Inerts: Metal + Glass + Plastic < 1.0 % by wt



USEPA 40 CFR Part 503 Standards

Soil Control Lab, n=3659

	503 limits	average
arsenic	41	7.2
cadmium	39	2.4
chromium*	1200*	30
copper	1500	121
lead	300	35
mercury	17	0.4
molybdenum		4.2
nickel	420	17
selenium	36	2.1
zinc	2800	

Relative Importance of Quality Attributes for Various Uses

Attribute	Potting media	Land reclamation	Soil amendment for hort crop	Mulch
Plant growth	++	++	++	--
Nutrient cont.	--	+	+	--
pH & sol salts	++	+	+	--
Maturity	++	--	+	--
Particle size	++	--	+	+