Effects of Conventional and Alternative Weed Management Strategies on Soil Quality in Grape Production in Iowa

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Outline

- Introduction
- Soil Quality
- Vineyard Experiment
- Vineyard Soil Quality Test Kit
- Conclusions

Why did we do this research?

Why do we do any research?

To solve a problem

How many of you have weeds?

How many of you are interested in alternatives to herbicides?

e.g., erosion, organic production

Why are we here?

What is your primary goal as a wine maker?

What is your primary goal as a grape grower?

Basics

- Our goal is to provide our vines with the best conditions possible for growth
- Managing grapes means managing the resources grapes need to grow
- What are these resources?
- Light, air, water, nutrients
- Do plants need soil?

Where do plants get these resources?

A properly functioning soil acts as a reservoir of water, air, and nutrient resources

AND

Acts as a resource that can be managed effectively or mismanaged

What is Soil Quality?

Soil Quality refers to the ability of soil to:

- produce a crop
- store and cycle nutrients
- resist erosion & compaction

Considers:

- Soil Chemical analysis
- Soil Physical condition
- Soil Biology (e.g., microbes and worms)

Why should grape growers care about soil quality?

- Can help growers improve and conserve their vineyard soil

($$ Healthy soil leads to optimum grapevine productivity)

- Can alert growers to problems with their soil
- Vineyard soils can be compared over time
- Different soil management strategies can be compared to each other

How can we manage soil quality?

- Enhance organic matter
- Avoid excessive tillage
- Manage pests and nutrients efficiently
- Prevent soil compaction
- Keep ground covered

1. Enhance organic matter

<u>Benefits</u>

- Soil structure
- Water & nutrient holding capacity
- Protects against erosion & compaction
- Soil organisms

<u>Practices</u>

- Crop residues
- Healthy plants
- Cover crops
- Manure/compost
- Reduced tillage
- Mulching

2. Avoid excessive tillage

Excessive tillage

- Breakdown soil structure
- Compaction
- Erosion
- Loss of OM
- Loss of soil organisms

Courtesy of USDA Natural Resources Conservation Service.

3. Manage pests and nutrients efficiently

Inefficient Practices

- Misapplied or over-applied chemicals
- Misapplied or over-applied conventional/ organic fertilizers

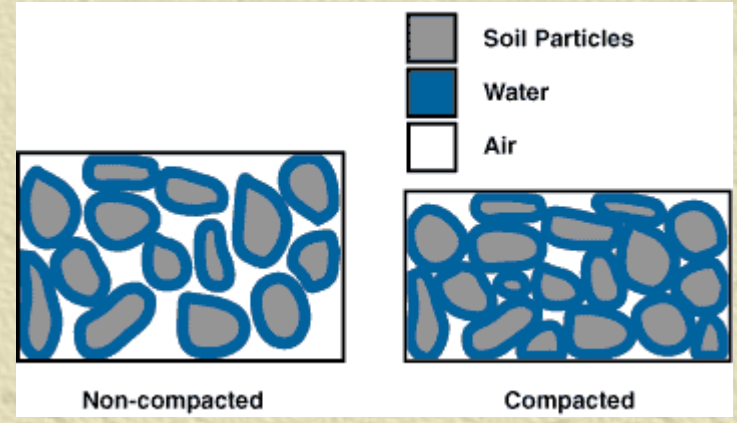
Efficient Practices

- Buffer & detoxify
- Testing & monitoring
- Necessary chemicals at right time and place
- Non-chemical approaches

4. Prevent soil compaction

Causes

- Repeated traffic
- Heavy traffic
- Travel on wet soil



Effects

- Reduced:
  - Air
  - Water
  - Space

  For roots & soil organisms

5. Keep the ground covered

Bare Soil

- Wind erosion
- Water erosion
- Drying & crusting

Ground Cover

- Protects surface
- Food & habitats for soil organisms
- Improve water avail.

Options

- Crop residue
- Living mulch

Concerns

- Delayed soil warming
- Barrier
- Competition
- Diseases

Research Question

What effect does weed management system have on:

1. Weed population
2. Soil properties
3. Grape Yield & Quality

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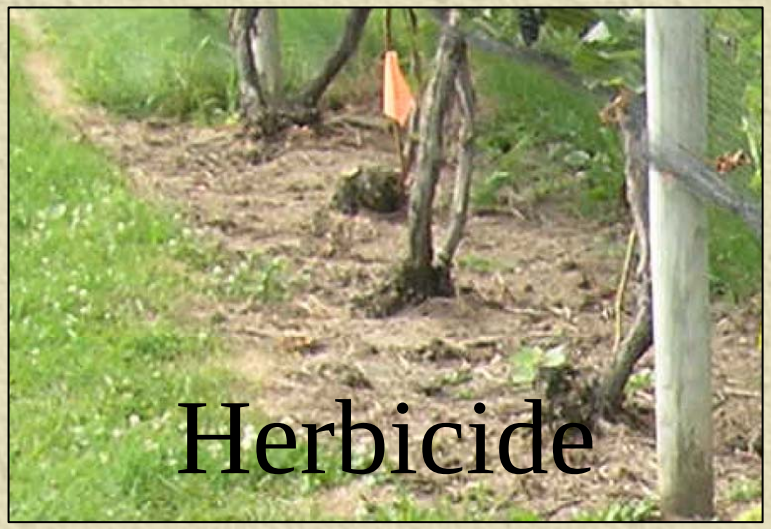
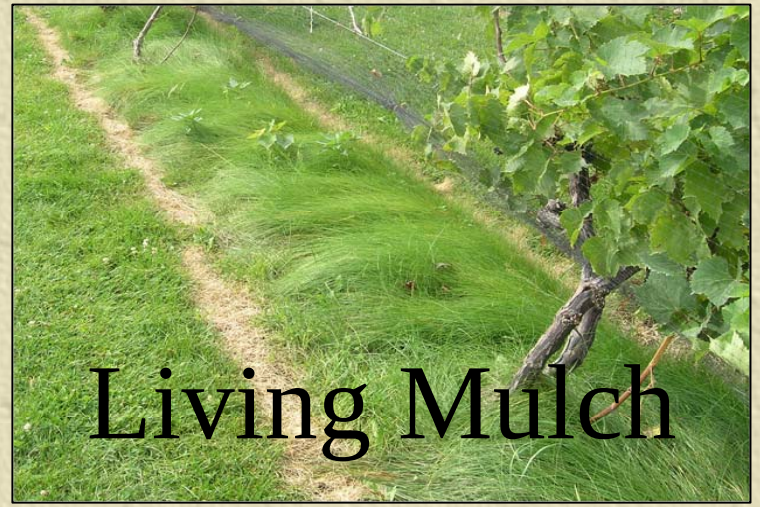
Horticulture Research Station, Ames





Design & Treatments

- Vineyard est. 1985
- ‘Marechal Foch’
- Randomized complete block design
- 4 replications x 4 treatments
- Treatments:

  1. Living mulch - Creeping red fescue
  2. Straw mulch
  3. Cultivation
  4. Conventional herbicide management

Vineyard Soil Management

- Between row soil (Alley way)
  - Sod strip (Common KBG)
- In-row soil (Under canopy)
  - Reduce negative impact of weeds

Treatment 1)
Living mulch:

Creeping red fescue (*Festuca rubra*), cultivar 'Pennlawn,' was seeded in treatment plots on September 25, 2003 at the rate of 19.5 g/m^2

- Chosen 'weed'
- Shallow rooted
- Shade tolerant
- Low maintenance
- Conserves soil
- Organic production

Treatment 2) Straw mulch:

- Applied at the rate of 13.6 $t \cdot ha^{-1}$(Cahoon et al., 1991) applied in April 2004
- Mulch was reapplied in April 2005 and 2007

- No competition
- Low maintenance
- Conserves soil
- Organic production

Treatment 3)
Herbicide applications:

- Preemergence herbicide was sprayed in early April
- Glyphosate applied May, July, and August

Treatment 4)
Clean cultivation

- Plots were shallow tilled (5 cm) with a roto-tiller in May, July, and August in all years
- No herbicides

Vineyard Weeds, 2004-2006

	Percentage Weed Coverage[y]					
	2004		2005		2006	
Treatment[z]	July	Aug.	July	Aug.	July	Aug.
Living Mulch	7.4 b	11.3 b	3.3 c	3.5 c	3.1 b	4.7 c
Straw Mulch	2.7 b	0.8 c	0.0 c	2.4 c	1.5 b	3.9 c
Herbicide	3.4 b	6.7 bc	87.9 b	30.0 b	64.7 a	20.4 b
Cultivation	89.4 a	20.4 a	95.2 a	93.0 a	69.8 a	87.0 a
LSD[x]	8.4	6.2	7.0	9.4	26.9	8.9

[z] Means of four replications and three years.

[y] Means obtained from the avg. of three, 0.25 m^2 quadrats per plot.

[x] Least significant difference @ $P<.05$; Values with the same letter are not different from each other.

Physical Characteristics, 2004-2006

	Initial Infiltration[z] (min.)		
Treatment	**2004**	**2005**	**2006**
Living mulch	**4.0[y] b**	**0.6 b**	**1.0 b**
Straw Mulch	**3.5 b**	**3.3 a**	**7.1 a**
Herbicide	**8.4 a**	**4.5 a**	**7.2 a**
Cultivation	**7.5 a**	**3.0 a**	**4.1 ab**
LSD[x]	**3.4**	**1.9**	**4.7**

[z] Amount of time for 2.54 cm of water to infiltrate into soil.

[y] Means of four replications.

[x] Least significant difference @ $P<.05$; Values with the same letter are not different from each other.

Biological Soil Characteristics

Treatment	2004-06 Earthworm[z] (no.· 30.5 cm^{-3})	2004 MBC[y] (µg C·g^{-1})	2006 MBC[y] (µg C·g^{-1})
Living mulch	16 b	535.7 a	428.2 a
Straw Mulch	25 a	271.4 b	327.0 ab
Herbicide	13 b	271.5 b	324.9 bc
Cultivation	19 ab	252.5 b	397.8 ab
LSD[w]	7	39.6	72.4

[z] Means of four replications and three years.

[y] Means of four replications.

[x] Least significant difference @ $P<.05$; Values with the same letter are not different from each other.

Chemical soil quality indicators, 2004-2006

Treatment[z]	Organic Matter (%)	Total organic Carbon (%)	Total Organic nitrogen (%)	pH	CEC (meq/100 g)
Living mulch	3.17 a	1.74 a	0.17	6.7	13.9
Straw mulch	3.17 a	1.74 a	0.17	6.8	13.6
Herbicide	2.74 b	1.50 b	0.15	6.8	16.7
Cultivation	2.82 b	1.55 b	0.16	6.5	13.2
LSD[y]	0.35	0.19	NS	NS	NS

[z]Means of four replications in each year for three years.

[y]Least significant difference @ *P*<.05; Values with the same letter are not different from each other. NS = Not significant.

Grape Yield and Growth, 2004-07

Treatment[z]	Yield per vine (kg)	Cluster number	Cluster weight (g)	Pruning weight/vine (kg)
Living mulch	2.1 ab	47 ab	42.4	0.37 b
Straw mulch	2.5 a	57 a	43.8	0.50 a
Herbicide	2.6 a	57 a	45.9	0.55 a
Cultivation	1.6 b	41 b	41.5	0.26 c
LSD[y]	0.5	10	NS	0.10

[z] Means of four replications and four years.

[y] Least significant difference @ $P < 0.05$; Means with the same letter are not different. NS=Not different.

Grape Quality, 2004-07

Treatment	pH	Total Acidity (g/L)	SSC[z] (%)
Living mulch	3.2[y] b	1.01	19.9
Straw mulch	3.4 a	0.91	19.9
Herbicide	3.3 ab	0.92	20.1
Cultivation	3.2 b	0.95	20.0
LSD[x]	0.1	NS	NS

[z] Percentage soluble solids concentration.

[y] Means of four replications and four years.

[x] Least significant difference @ $P < 0.05$; Means with the same letter are not different. NS=Not different.

What effect does weed management system have on:

Treatment	Weed Suppression	Soil Quality	Grape Yield	Grapevine Vigor
Living mulch	Very Good	Very Good	Good	Good
Straw mulch	Very Good	Very Good	Very Good	Very Good
Herbicide	Good	Good	Very Good	Very Good
Cultivation	Poor	Good	Poor	Poor

Conclusions

1. Straw mulch can be used for effective weed control*

*Effectiveness dependent upon:

- Application of straw
  - Squares vs. loose
- Quality of straw
- Minimal disturbance of straw

Conclusions

2. Living mulch has potential for effective weed control*

*Effectiveness dependent upon:

- Mature vineyards only
- Adequate rainfall or irrigation
- Establishment of thick turf
- Watch for invasion by other grass species

Conclusions

3. Herbicides work well*

*Potential drawbacks:

- Timing important/multiple applications
- Potential to damage grapevines
- Soil erosion
- Soil crusting
- Decreased soil organic matter

Conclusions

4. Cultivation effective for short periods*

*Potential drawbacks:

- Timing important/multiple applications
- Damage to surface roots of grapevines
- Soil erosion, Soil crusting
- Soil compaction
- Potential to reduce vine vigor

Overall Conclusions

Alternative weed management systems are:

1. Feasible (more undiscovered?)
2. Conserve vineyard soil
3. Maintain grape yield

Grape Grower Experiences with USDA/NRCS Soil Quality Test Kit

What is a Soil Quality Test Kit?

A soil quality test kit is a field kit that can be used by growers or consultants to take soil measurements and see the results without sending samples to a laboratory for analysis

What does the kit measure?

The field kit can be used to make 11 soil <u>measurements:</u>

Electrical conductivity (EC)

pH

Soil nitrate

Bulk density

Water infiltration

Biological properties

Soil respiration

Aggregate stability

Slake test

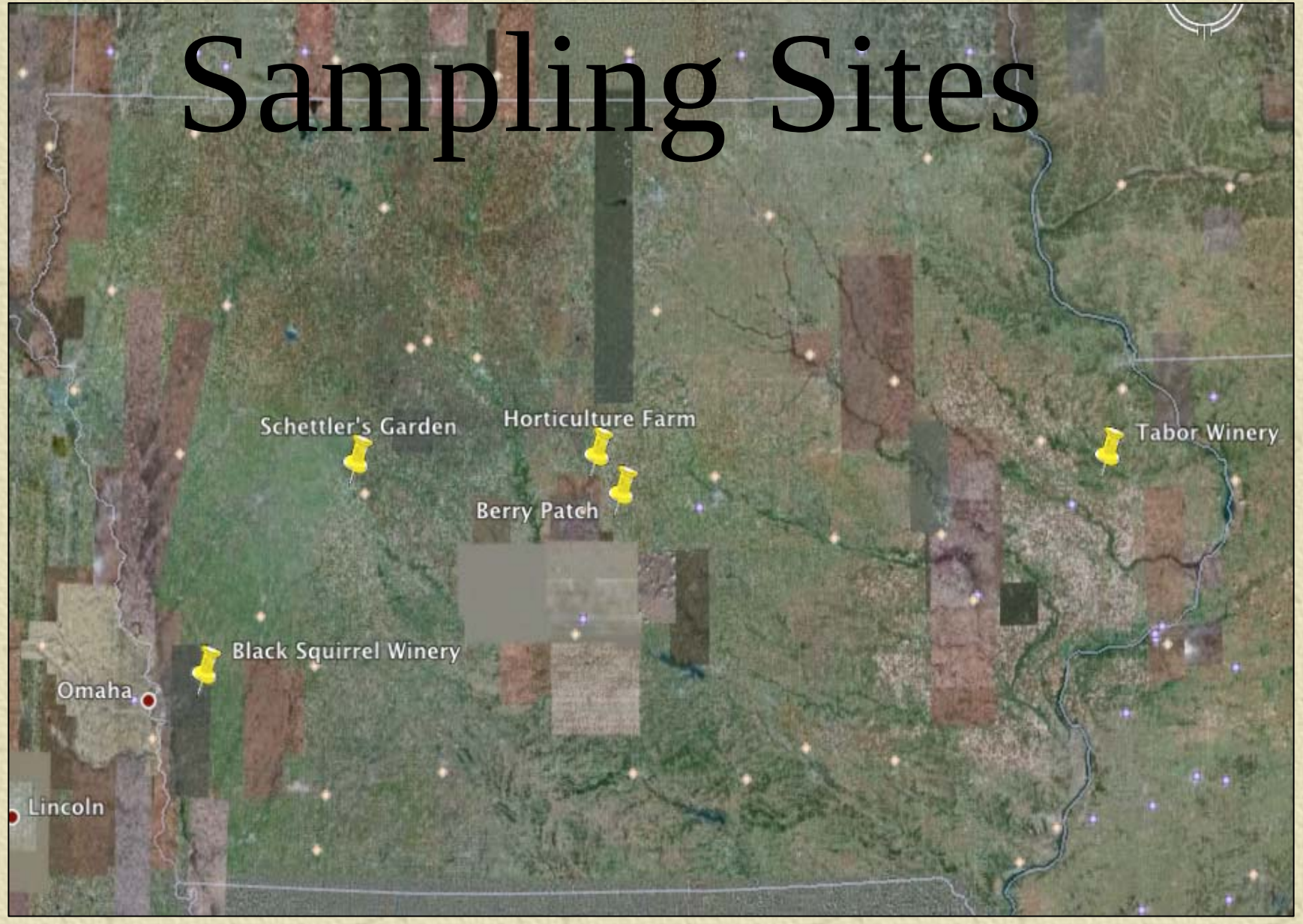
Earthworm test

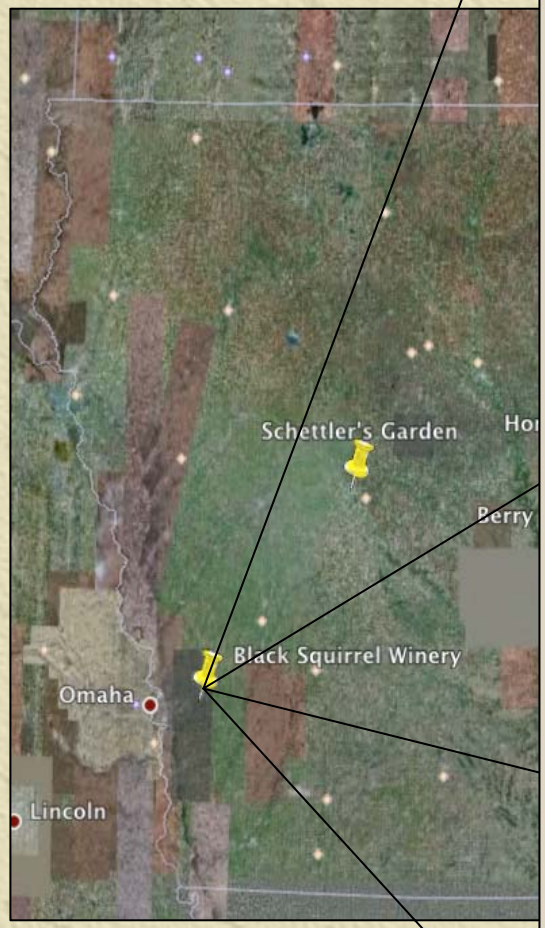
Physical observations and Estimates

Advantages of using a Soil Quality Test Kit (vs. only sending soil samples to lab)

- Measurements in the kit include physical and biological properties that are not routinely done at labs
- Some measurements in the kit would be expensive if done at a lab
- Results can be obtained the same day

Sampling Sites





Black Squirrel Winery Owner and Operator: Charles Caldwell

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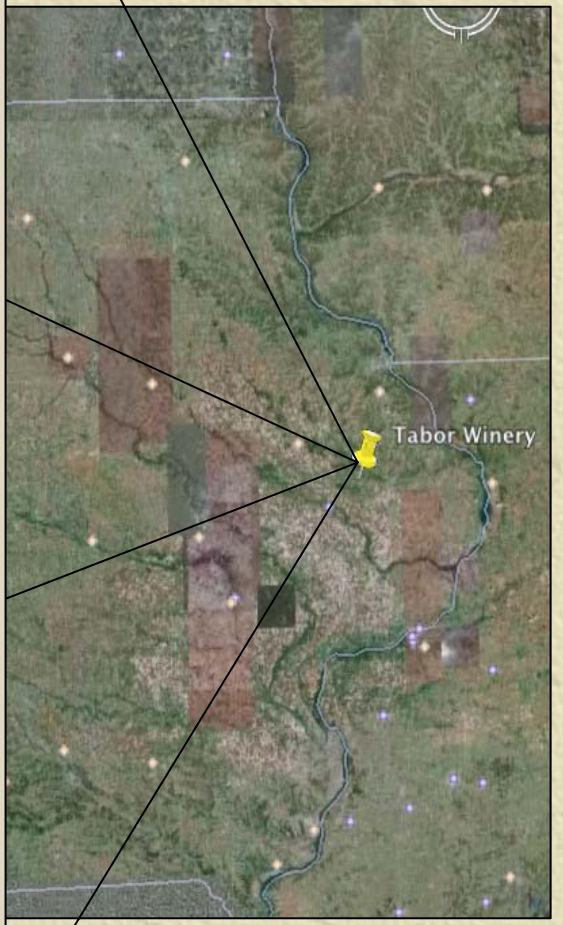
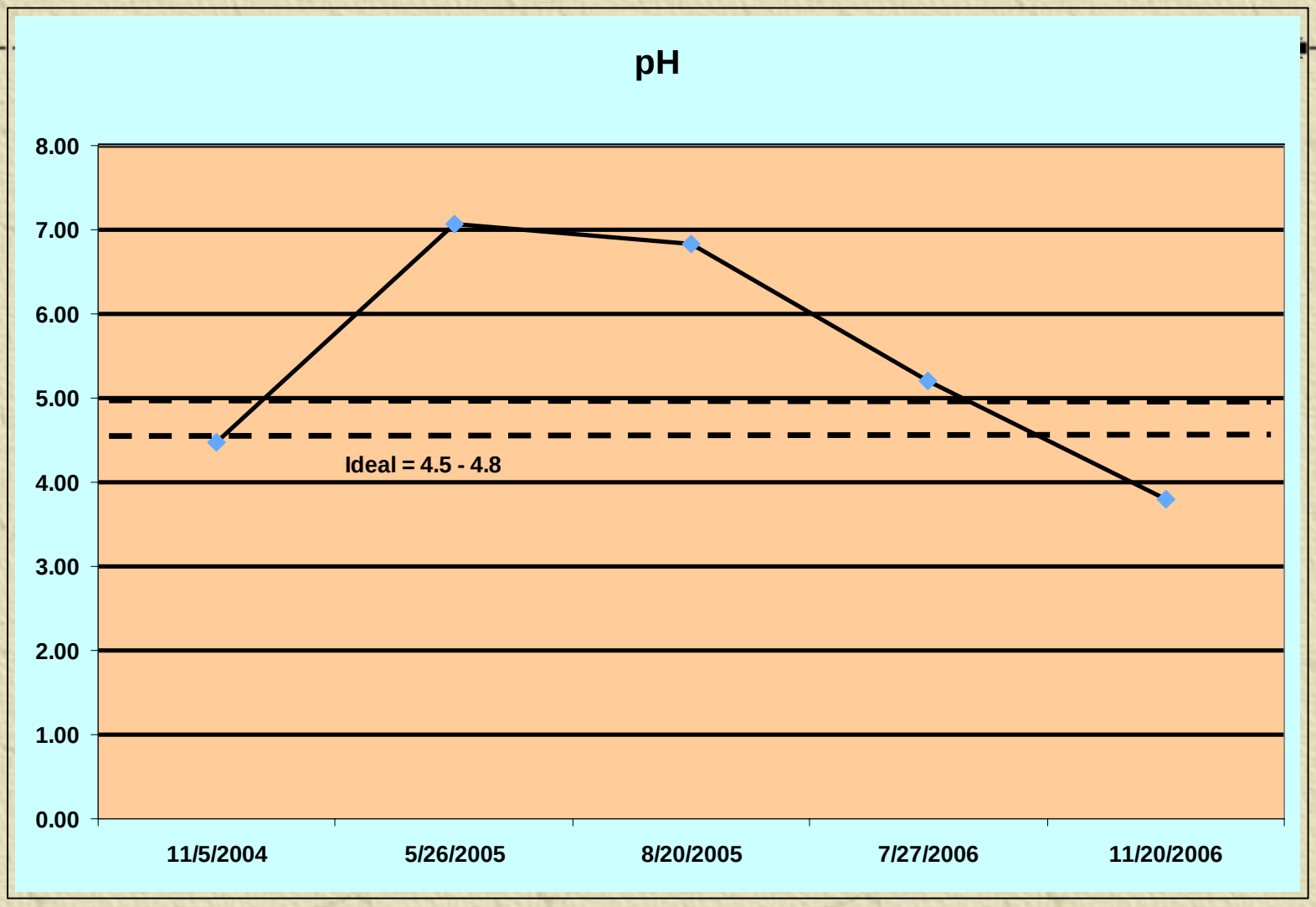
are needed to see this picture.

Tabor Home Winery

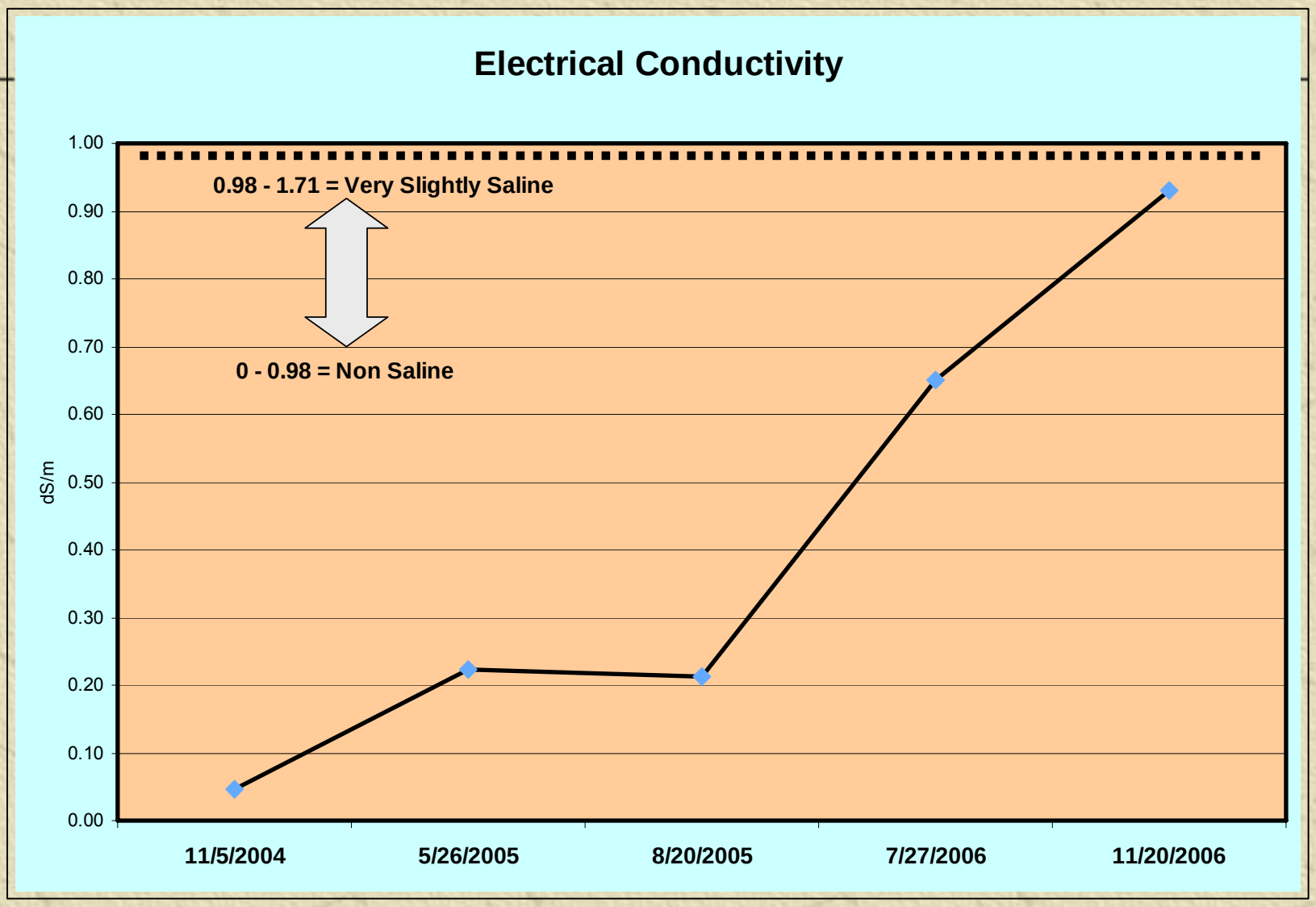


Tabor Home Winery Owner and Operator: Paul Tabor

Soil Quality Test Kit



Soil Quality Test Kit



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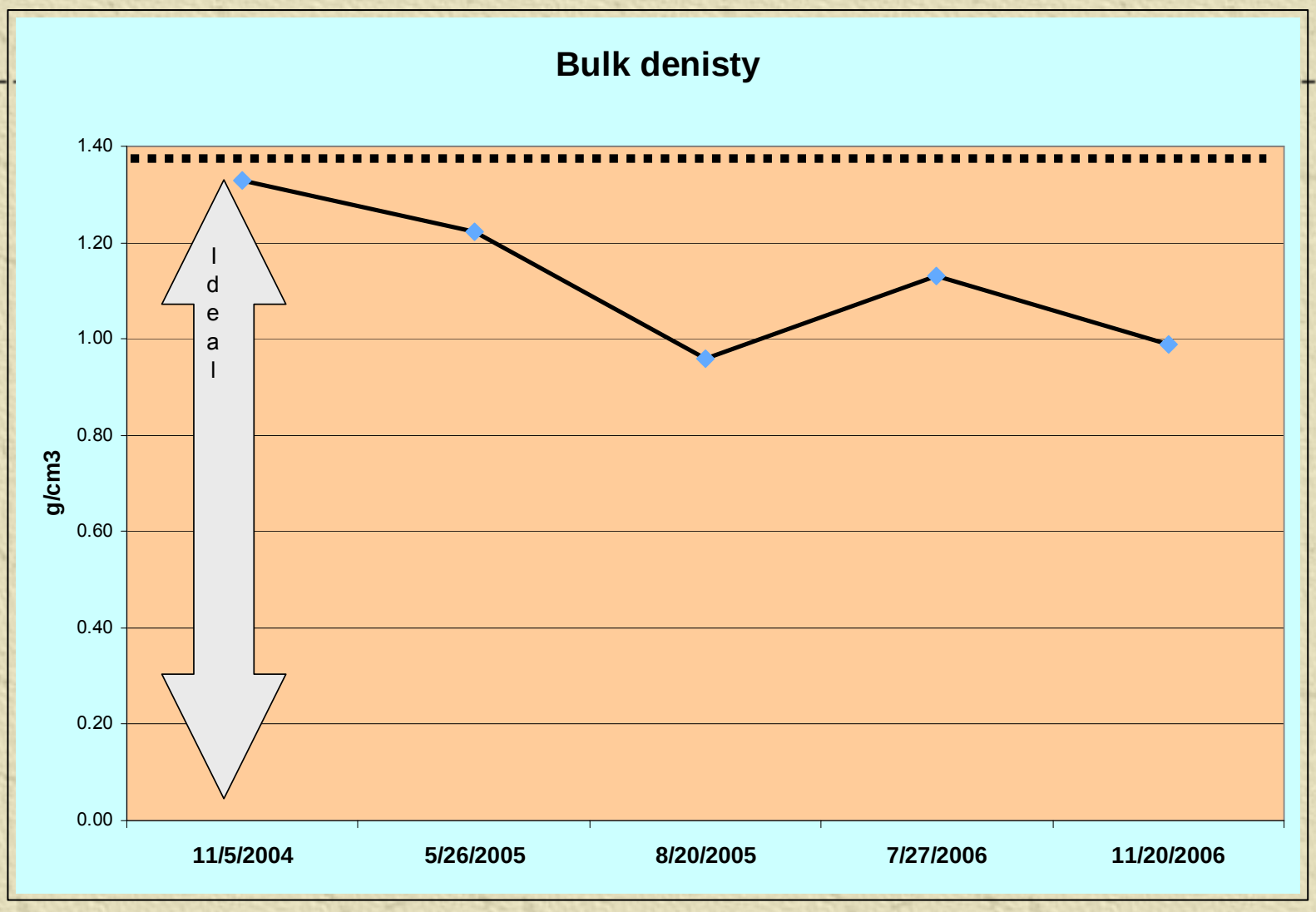

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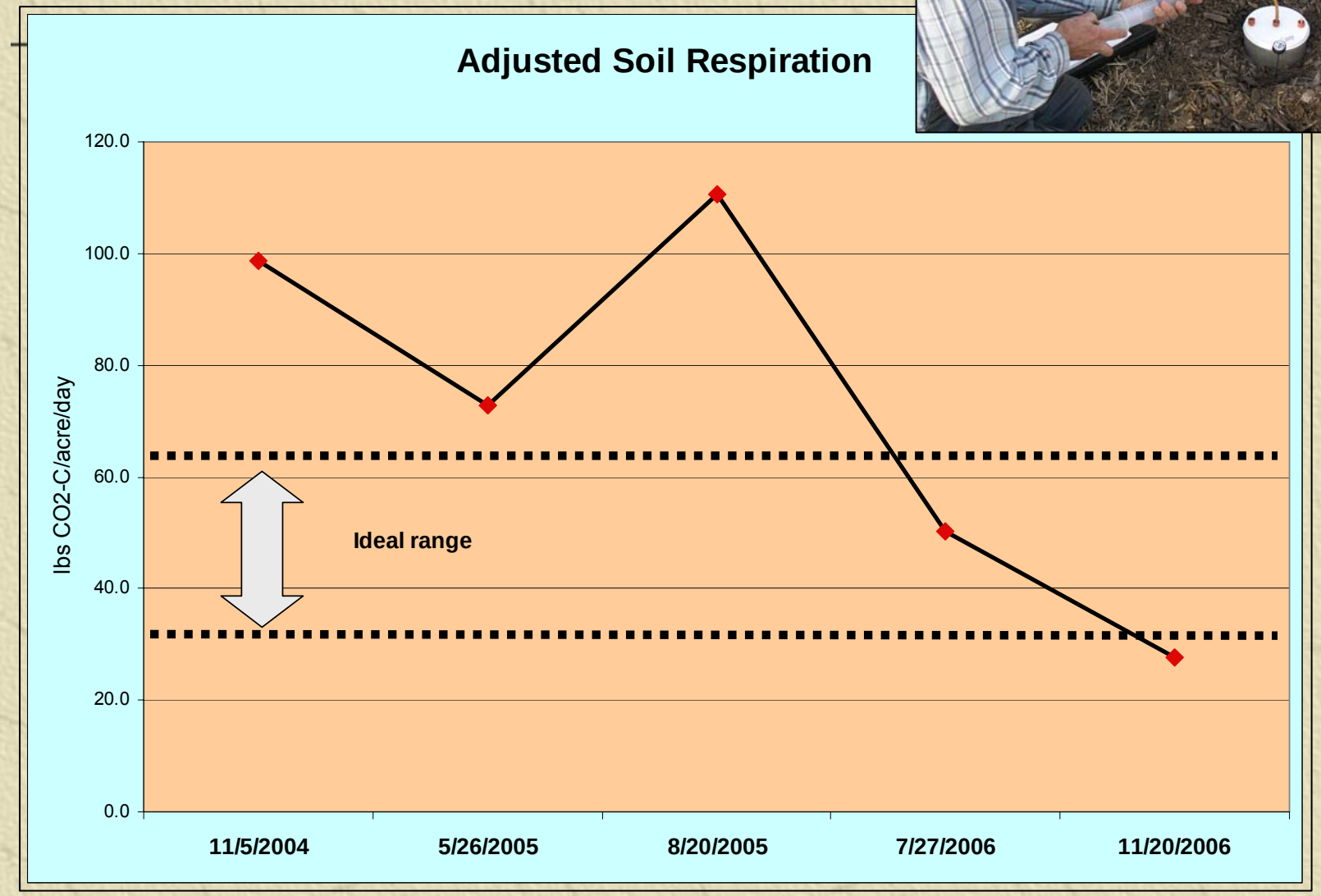
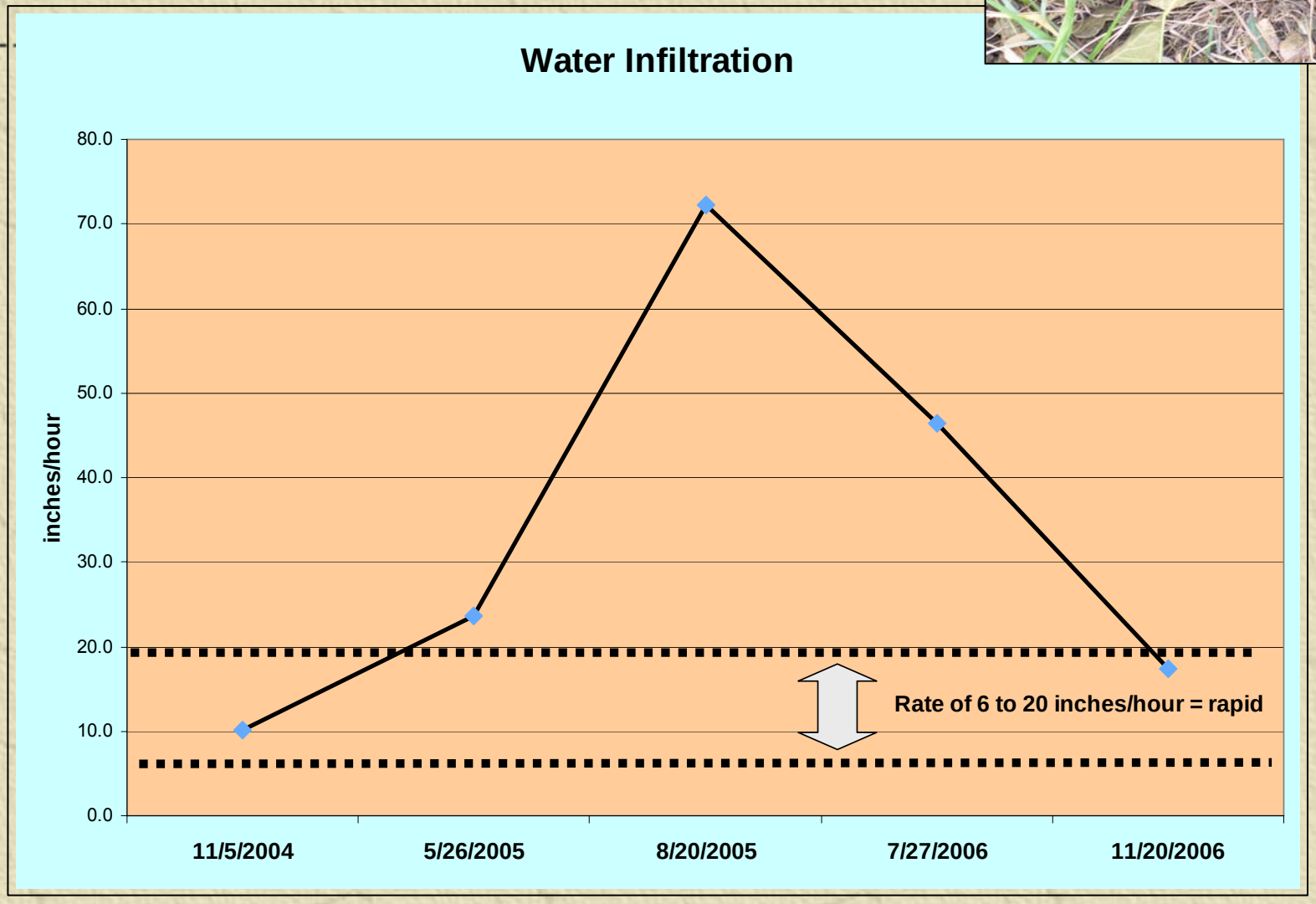


Soil Quality Test Kit



Summary

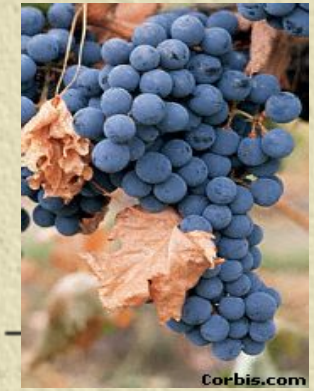
- Use of the kit showed changes in soil condition due to soil amendments
- Use of the kit showed changes in soil condition between two different soil management systems
- Continued monitoring over time will likely show more differences

Conclusions

- Good for monitoring trends
- Increases management options
- Helps to monitor changes in soil
  - physical structure
  - biological activity
  - pH and EC
- Since these are all factors of soil fertility, the kit can be used to help manage crop production
- Kit <u>DOES NOT</u> replace laboratory testing!

SOIL QUALITY TEST KIT

- Where can I get more information?
- Information display at this conference
- Field days
- NRCS website:
- http://soils.usda.gov/sqi/soil_quality/what_is/index.html



Thank you

Questions ?

Discussion

- Living and straw mulch inhibited weed growth as effectively as herbicide
- Living mulch enhanced water infiltration and microbial activity compared with herbicide
- Cultivation and living mulch reduced pruning weights, when compared with straw mulch and herbicide