



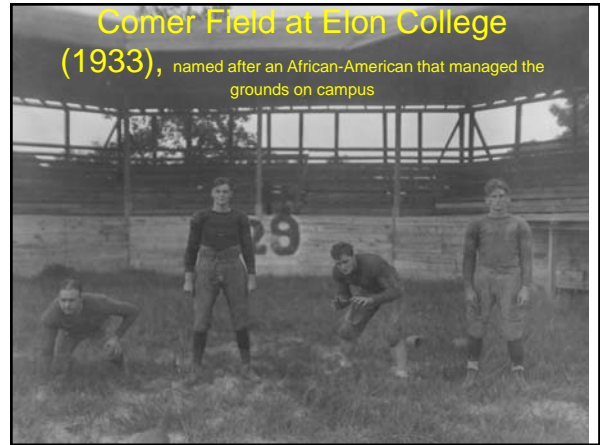
### Things Will Change

You Can Play a Direct Role

### How Fast?

Time is relative; its only worth depends upon what we do as it is passing.

Albert Einstein



### Two other Einstein quotes

- When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute and it's longer than an hour. That is relativity.
- We cannot solve our problems with the same thinking we used when we created them.





**Subject Winners of 2016 Ig Nobel Prizes**

**Physics** – For discovering why white-haired horses are the most horsefly-proof horses.

**Medicine** – for discovering that if you have an itch on the left side of your body, you can relieve it by looking into a mirror and scratching the right side of your body.

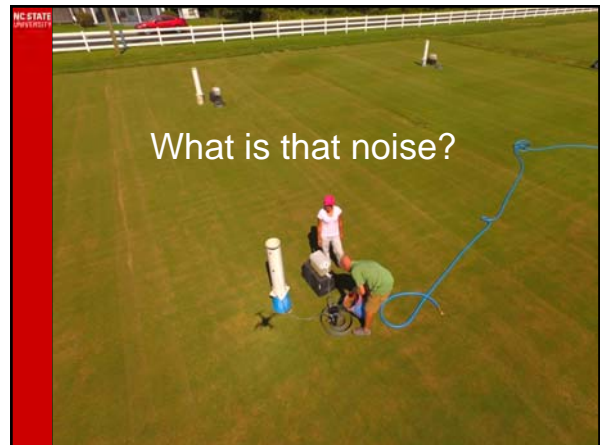
**Psychology** – for asking a thousand liars how often they lie, and for deciding whether to believe those answers.

**Peace** – for the scholarly study, "On the Reception and Detection of Pseudo-Profound Bullshit"

**Research**

- You can access.
- You can help with.
- You can do.

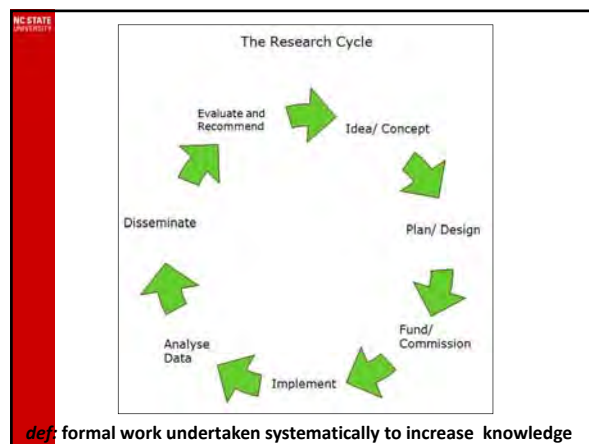
Research does not have the same value or meaning for everyone!



**Winner of 2016 Ig Nobel Prize**  
 "honor work that makes people laugh and then think"

Ig Nobel Prize Winner Dr. Elena Bodnar demonstrates her invention (a [brassiere that can quickly convert into a pair of protective face masks](#)) assisted by Nobel laureates Wolfgang Ketterle (left), Orhan Pamuk, and Paul Krugman (right).





### Information is the Result of Research

- What grass should I use?
- What pesticide controls this weed?
- How long will I see a response from this fertilizer?
- Should I cover my field tonight (xx degrees)?
- Will my field hold up to this weekend's tournament?
- Pesticide spill, how to I clean it up?
- Employee injured, how do I treat wound?
- Blood on my field, what do I do?

Knowledge Gained through Experience is Research  
Research may Result in New Products and/or Practices

### Experimental Approach

1. Hypothesis **what?**
2. Experimental design **how?**
3. Experimental execution **process.**
4. Statistical analysis **confidence?**
5. Interpretation **results . . .**

### Important Products?

- Tifway bermudagrass (other prominent grasses)
- Glyphosate (Round-Up)
- Fipronil (Top Choice)
- Chlorothalonil (Daconil)
- 2, 4-D
- Aerifier
- Automated irrigation control
- GPS

### We usually start with a question.

**3. Find x.**

*Here it is*

**SIMPLICITY**

The simplest solutions are often the cleverest  
They are also usually wrong



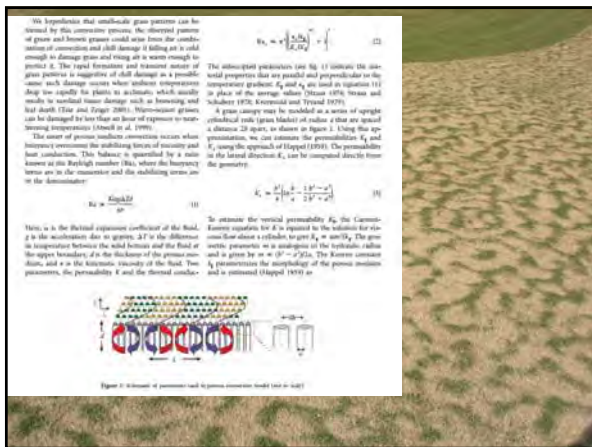


Determine how fraise mowing fits into bermudagrass management while assessing its benefits towards soil profile characterization.



## Discovery vs Validation

- Most of the turf research is directed towards validating performance.
  - Performance compared to industry standards.
- Of course discovery (new uses, rates, products, etc) may happen along the way.





## Pesticide fate research in turfgrass... Why is it important???

- Keeping the right products on shelves
- Reduces potential for adverse effects on off-target areas
  - off-target movement = angry neighbors*
- Improves comprehensive IPM plans



## New Pesticide to Market

- Estimated cost of discovery, development and registration to bring a new pesticide active ingredient to the marketplace about \$180 million.
- Time frame: 8-10 years
  - On average 1 in 70,000 go forward from screening phase.
  - On average 1 in 2 make it through an application for registration
  - Only 1 in 139,000 molecules synthesized will ever make it to market.

## Researched Items

- Pest Control Products: rate, non-target safety
- Pesticide application method and timing
- Grass, cultivar
  - Establishment
  - Mowing
  - Irrigation
  - Fertilization
  - Stress tolerances (cold, shade, traffic, etc)
  - Pest tolerances (insects, diseases, weeds)
- Field/Green performance characteristics
- Construction/Renovation material and techniques
- What happens when?

## Pesticide fate research in turfgrass... Why is it important???

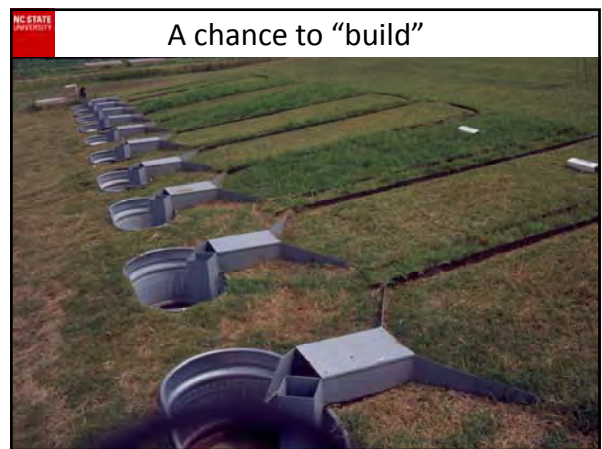
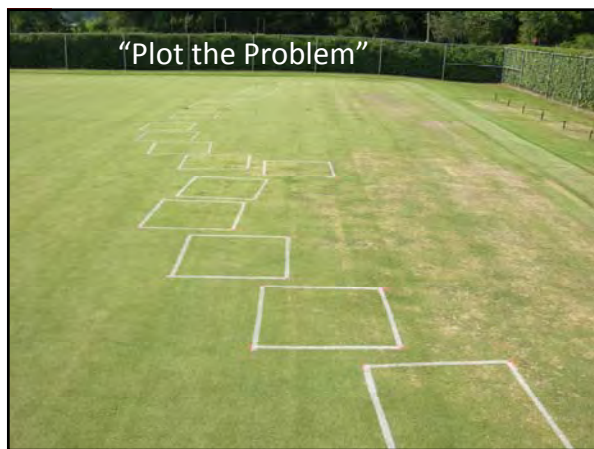
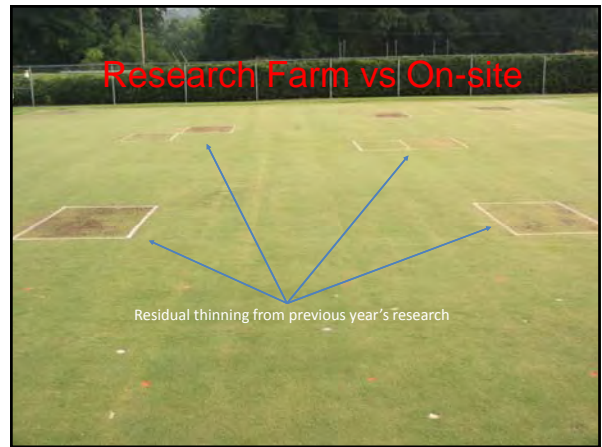
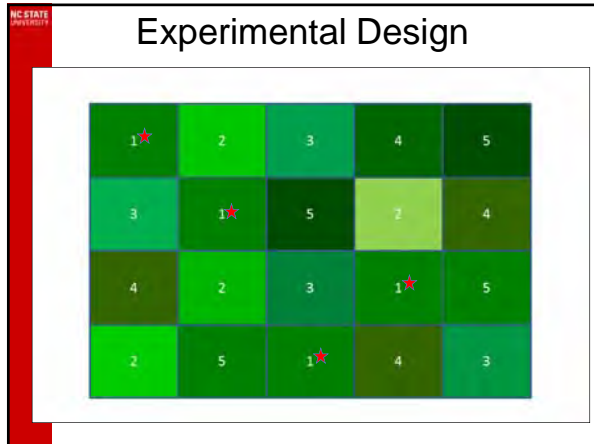
Preserve tools (pesticides) today, while providing information required for the implementation of best application practices in the future

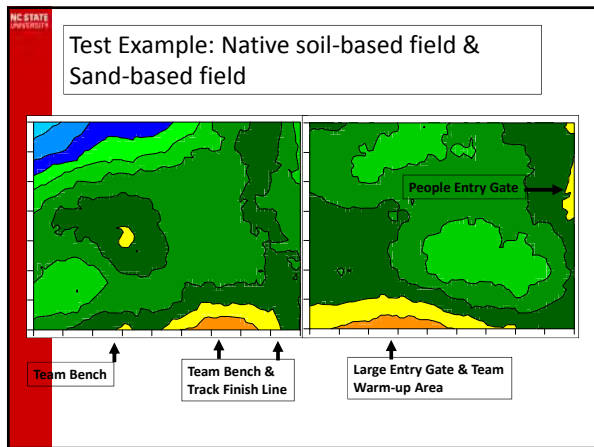
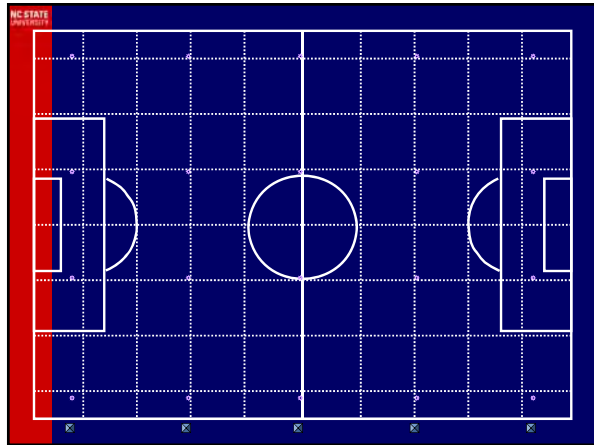


## Experimental Approach

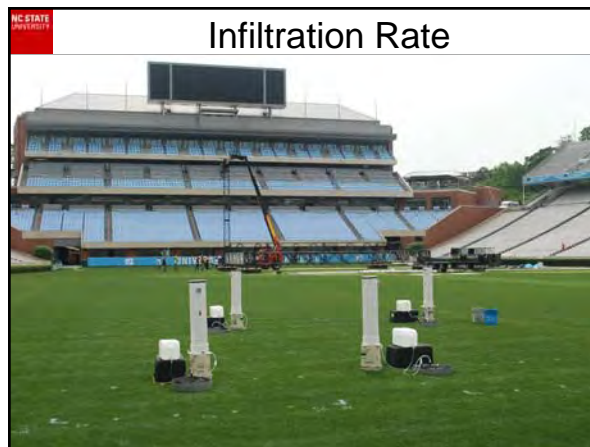
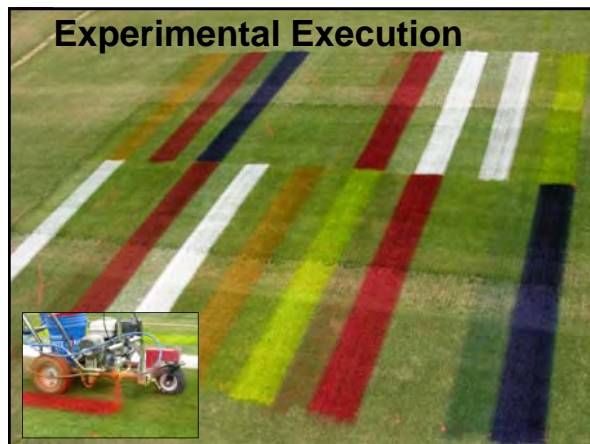
1. Hypothesis
  2. Experimental design
  3. Experimental execution
  4. Statistical analysis
  5. Interpretation
- what?  
how?  
process.  
confidence?  
results . . .









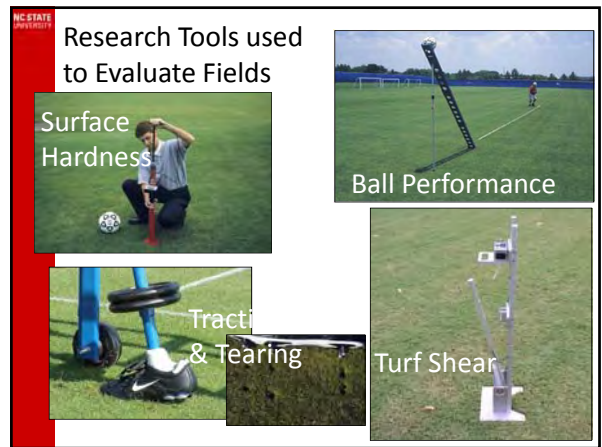
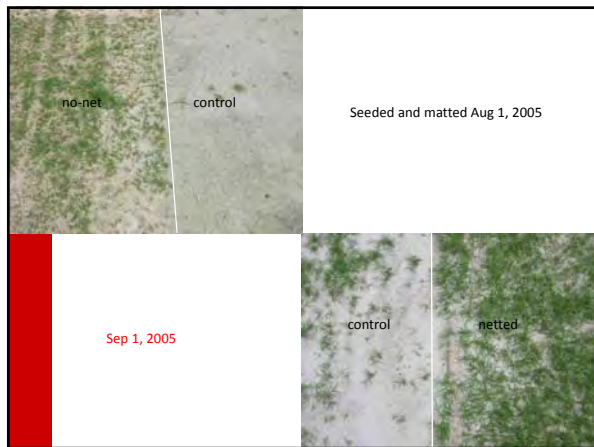
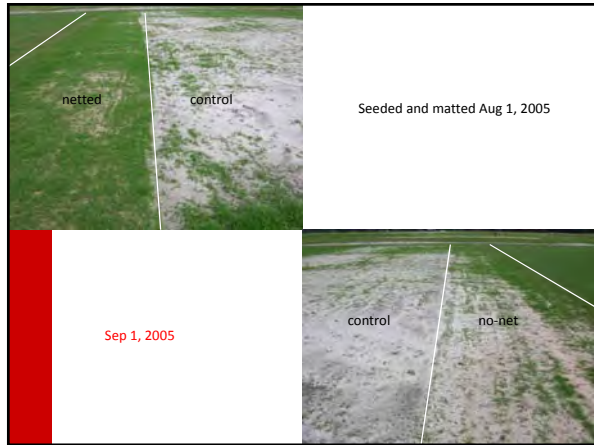
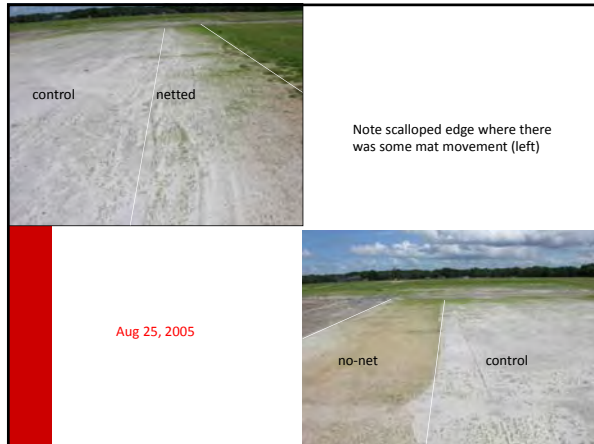


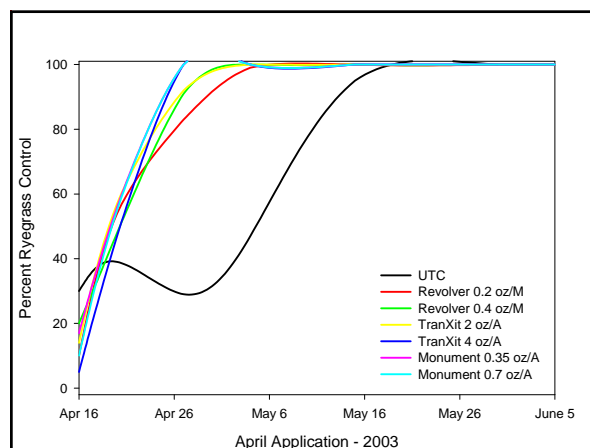
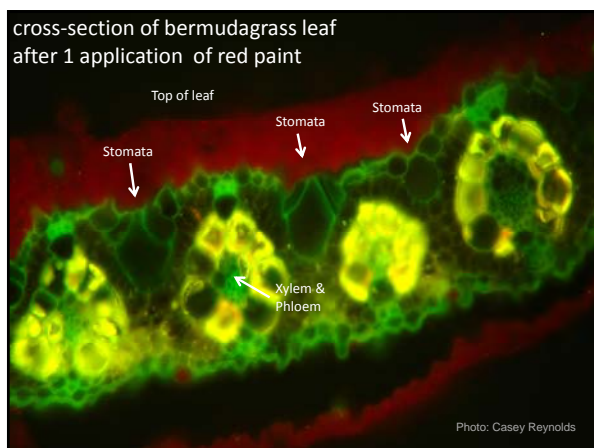
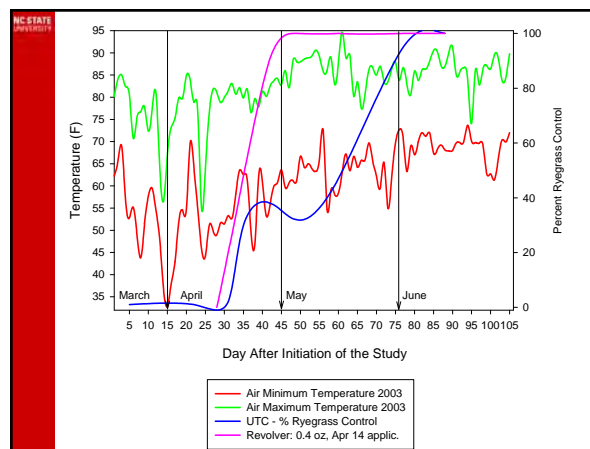
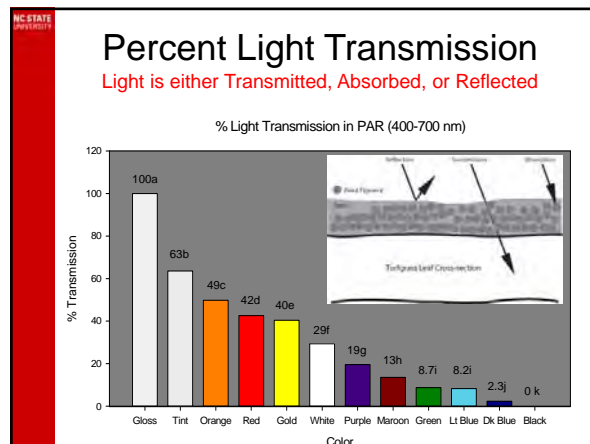
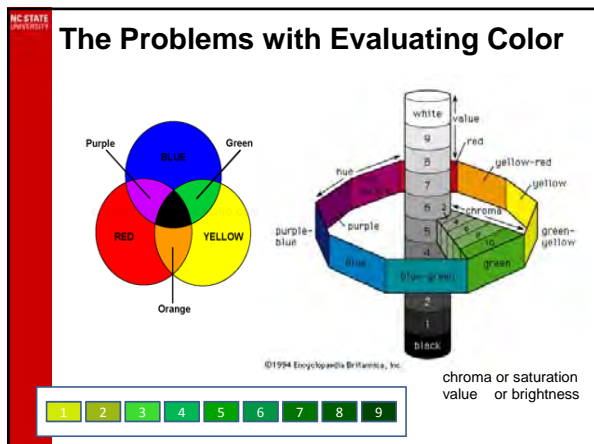
**Experimental Approach**

1. Hypothesis	what?
2. Experimental design	how?
3. Experimental execution	process.
4. Statistical analysis	confidence?
5. Interpretation	results . . .









## Experimental Approach

1. Hypothesis what?
2. Experimental design how?
3. Experimental execution process.
4. Statistical analysis confidence?
5. Interpretation results . . .

## T-test and LSDs

t Tests (LSD) for Ca

Alpha	0.05
Error Degrees of Freedom	26
Error Mean Square	0.000107
Critical Value of t	2.05553
Least Significant Difference	0.0108

Means with the same letter are not significantly different.

t Grouping	Mean	N	tmt
A	0.150000	8	4
A			
B	0.147143	7	5
B			
B			
B			
B			
C	0.142500	8	3
B			
C	0.137500	8	2
C			
C			
C	0.133750	8	1

## Purpose of Statistics

- Using objective criteria to aid in decision making in the face of uncertainty
- Statistics can control the rate of making an incorrect decision
- It is not the "final answer"




TABLE 11. MEAN TURFGRASS QUALITY RATINGS OF TURFGRASS CULTIVARS AT HALDWIN, NC 11, 2015 DATA.

TURFGRASS QUALITY RATINGS 1-9; 9=BEST 2/

CULTIVAR	MAY	JUN	JUL	AUG	SEP	OCT	MEAN
1271UR (DT-1)	8.8	8.0	8.8	9.3	4.0	8.7	8.0
PARTRUST	5.0	8.7	8.7	7.7	5.0	5.0	6.9
75C-2-12-18-V	6.0	7.4	6.7	7.0	5.3	5.1	7.0
11-T-33B	9.0	8.3	8.7	7.7	4.0	5.5	7.8
LASTWOOD 36	5.0	6.0	7.0	7.3	4.0	5.0	6.0
04C-1302	5.5	5.7	7.0	7.3	4.3	5.3	7.0
75C-2-21-1-V	4.7	8.3	8.7	8.7	4.3	5.0	7.1
04C-1135	8.0	8.7	8.3	7.3	4.0	4.7	7.2
ASTRO	4.7	5.7	6.0	6.0	3.3	4.7	5.3
TRIFID	4.0	5.7	6.7	6.7	4.0	5.7	5.5
04C-1103	5.7	6.0	6.3	6.7	3.0	3.7	5.3
FATES 1325	4.0	5.7	6.7	6.7	4.0	4.7	5.5
FATES 1327	4.7	5.3	6.7	6.0	5.3	4.3	4.8
4122EVA	4.0	4.7	5.7	6.7	4.0	4.3	4.8
CELEBRATION	5.7	4.0	5.3	6.3	4.0	5.3	4.8
35C-2007-13-5	4.0	4.3	5.7	5.3	4.3	4.3	4.7
FATES 1326	2.7	4.3	6.0	6.0	4.3	4.3	4.6
11-T-251	4.0	4.7	5.3	5.3	3.3	4.0	4.5
HBO 062	3.7	4.3	4.7	5.3	3.3	5.0	4.4
HBO 281	4.7	5.0	4.7	4.7	3.3	4.0	4.4
35C-2007-8-5	3.7	4.3	5.3	4.7	3.7	4.0	4.3
04C-0811-1	4.0	4.0	5.3	4.7	3.7	4.0	4.3
PRINCESS 77	3.0	4.0	5.3	5.0	4.0	4.3	4.3
PRIN	5.0	4.7	6.7	5.3	4.0	4.3	4.3
8#E-C201	3.0	4.3	3.0	5.3	3.7	4.0	4.2
35C-2009-11-5	4.3	4.3	4.3	4.3	3.3	4.0	4.1
04C-2011-4	3.7	4.3	4.0	5.0	3.7	3.7	4.1
12-75B-1	3.0	3.7	4.7	5.3	3.3	4.0	4.0
35C-2009-1-5	4.0	4.0	4.0	4.0	3.3	4.0	3.9
04C-2009-3	3.3	4.3	4.0	4.7	3.7	3.7	3.9
KAWNEA (PST-HIGH)	3.3	3.3	3.7	3.7	4.0	4.3	3.7
NORTH HEDGE SLT	3.0	3.3	3.7	3.7	3.7	3.3	3.5
PST-H175	3.0	3.3	3.3	3.3	3.3	4.0	3.4
NEVER-GAMMA	3.3	3.0	3.3	3.3	3.7	3.3	3.2
PST-B6CT	3.0	3.0	3.3	3.0	3.0	3.3	3.2
LSD VALUE	0.0	0.0	1.3	0.0	1.0	1.1	0.0
S.E. (E)	23.5	22.0	25.3	24.4	28.0	24.0	8.7

## Analysis of Variance (ANOVA), Least Significant Difference, and Regression

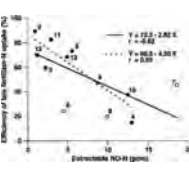
Source	d.f.	SS	MS	F
Treatment	$a - 1$	$SS_{\text{treat}}$	$\frac{SS_{\text{treat}}}{a - 1}$	$\frac{MS_{\text{treat}}}{MS_{\text{error}}}$
Error (a)	$N - a$	$SS_{\text{error(a)}}$	$\frac{SS_{\text{error(a)}}}{N - a}$	
Time	$t - 1$	$SS_{\text{time}}$	$\frac{SS_{\text{time}}}{t - 1}$	$\frac{MS_{\text{time}}}{MS_{\text{error}}}$
Treat x Time	$(a - 1)(t - 1)$	$SS_{\text{treat} \times \text{time}}$	$\frac{SS_{\text{treat} \times \text{time}}}{(a - 1)(t - 1)}$	$\frac{MS_{\text{treat} \times \text{time}}}{MS_{\text{error}}}$
Error (b)	$(N - a)(t - 1)$	$SS_{\text{error(b)}}$	$\frac{SS_{\text{error(b)}}}{(N - a)(t - 1)}$	
Total	$N - 1$	$SS_{\text{total}}$		

t Tests (LSD) for Ca

Alpha 0.05  
Error Degrees of Freedom 26  
Error Mean Square 0.000107  
Critical Value of t 2.05553  
Least Significant Difference 0.0108

Means with the same letter are not significantly different.

t Grouping	Mean	N	tmt
A	0.150000	8	4
A			
B	0.147143	7	5
B			
B			
B			
B			
C	0.142500	8	3
B			
C	0.137500	8	2
C			
C			
C	0.133750	8	1



## Overseeding + Colorant Treatments

Grouping	Mean Quality	Treatment
A	7.4	12# seed + paint
B	6.9	12# seed, no paint ←
B	6.9	8# seed + paint ←
C	5.7	8# seed, no paint
D	5.0	4# seed + paint
E	4.1	4# seed, no paint
E	4.0	0 seed + paint
F	2.4	0 seed, no paint

\*means with same letter not different (P=0.05) using LSD test  
[Probability of making a wrong conclusion]



### Excel for t-test

### Experimental Approach

1. Hypothesis what?
2. Experimental design how?
3. Experimental execution process.
4. Statistical analysis confidence?
5. Interpretation results . . .

Table. Color fastness, quality, and color loss of four test paints painted in one direction.

Paint	Color Fastness	Color Quality	Color Loss		CV % = st. dev/mean
	Initial -- minutes --	Initial -- 1 to 4 -- (4 = best)	4 DAT <sup>†</sup>	7 DAT	
Krylon	21 a	1.0 c	46 a	88 a	Dull white, Flat, some phyto
Rust-Oleum	16 ab	2.0 b	24 b	71 b	Bright white, glossy
Seymour	11 b	3.8 a	12 c	53 c	Bright white, flat,
Super Line	9 b	3.2 b	10 c	48 c	Bright white, glossy
CV%	40	16	26	13	

### Carefully evaluate results

Interpretation: Same results do not apply to every situation

- Environmental differences
- Different application
- Different margin of safety
- Marketing?

### Stats – False causality

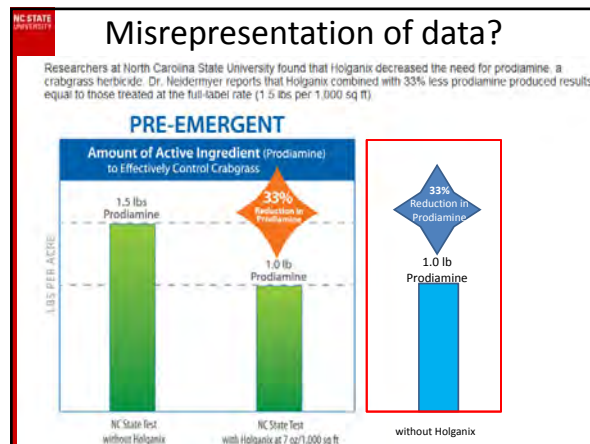
When a statistical test shows a correlation between A and B, there are usually six possibilities:

1. A causes B.
2. B causes A.
3. A and B both partly cause each other.
4. A and B are both caused by a third factor, C.
5. B is caused by C which is correlated to A.
6. The observed correlation was due purely to chance.

### Does the research system fail?

- >30,000 claims

### Imprelis Herbicide



### Data Manipulation or "Fudging"

Choosing a group of results that follow a pattern consistent with the preferred hypothesis, while ignoring other results that contradict the hypothesis.

This is why well-designed studies have control treatments ---- and they are used.

### Common University Efforts in Turfgrass Research?

- Maintain turf quality with fewer inputs (water, fertilizer, chemicals, labor)
  - Develop and evaluate new grasses/cultivars
  - Evaluate new chemicals and turf care products
  - Evaluate new fertilizer formulations/programs
  - Evaluate new technologies and management strategies to allow greater water conservation

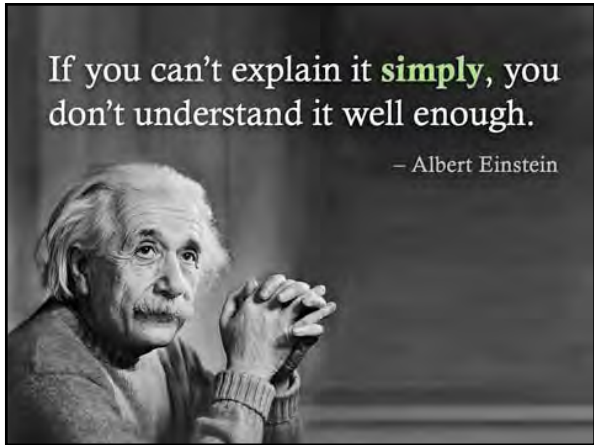
Who develops "Protocols"?





Research

- Getting the Information!!!!



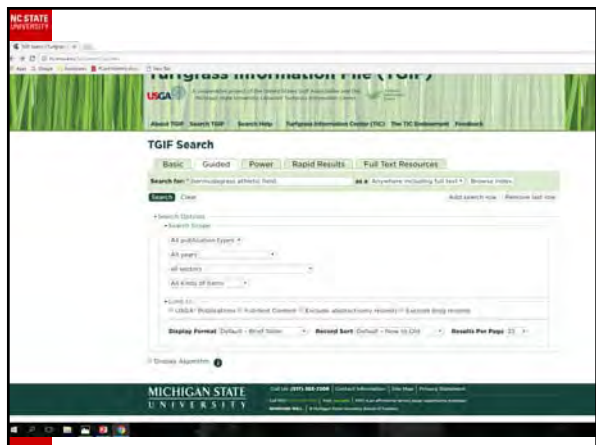
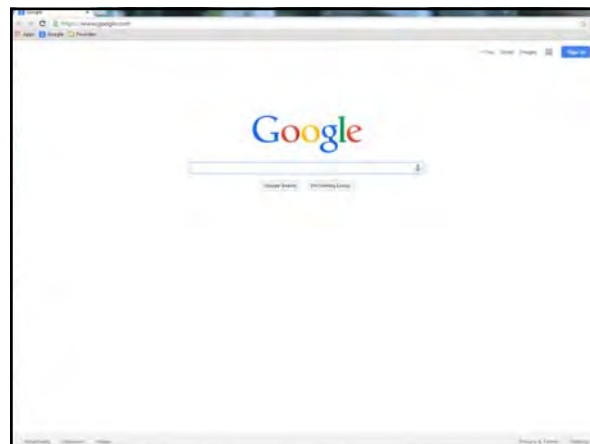
[www.turffiles.ncsu.edu](http://www.turffiles.ncsu.edu)



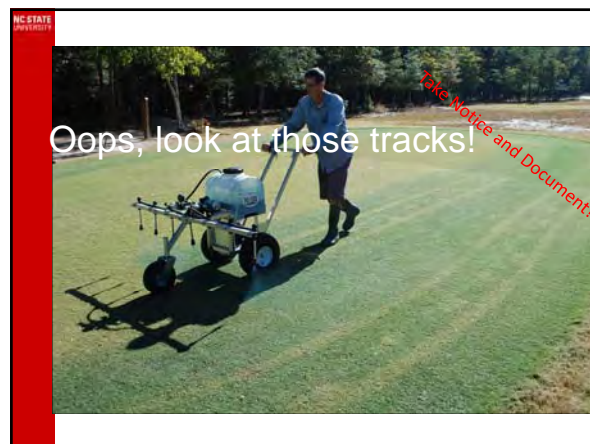
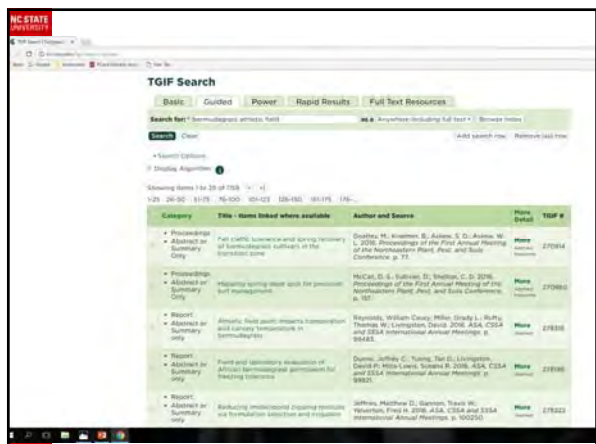




tic.msu.edu/tgif

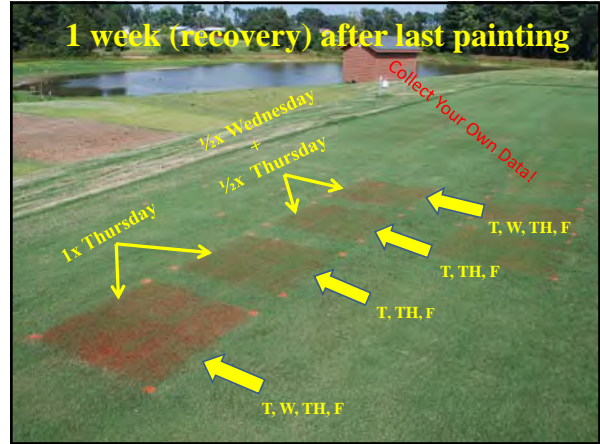


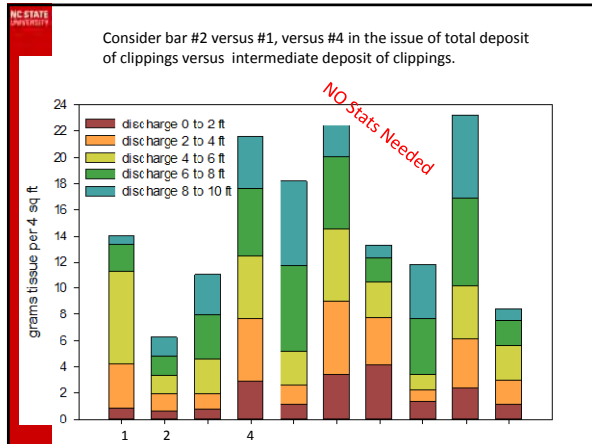
Research From the Tailgate of your Truck



Oops, look at those tracks!

*Fake Notice and Document!*





NC STATE UNIVERSITY

Side Discharge	Bagging	Mulch
Clippings in path	Clippings in path – start	Clipping in path
Clippings in piles	Clippings in path – middle	Clipping in piles
Discharge evenness	Clippings in path – end	Clipping fineness
Windrows	Clumping in beginning	Swirl marks
Throw distance (ft)	Clumping in middle	Uncut leaves
Uncut leaves	Clumping in end	Cut in tire path
Cut in tire path	Uncut leaves	Clippings under deck
Discharge (wt) in 2ft increments	Cut in tire path	Clipping in path (wt)
Total discharge (wt)	Quality in beginning	Clippings at deck edge (wt)
Overall cut quality	Quality in middle	Overall cut quality
	Quality in end	What is of Interest?
	Bag clogging (area covered)	
	Bag fill – top (wt)	
	Bag fill – left (wt)	
	Bag fill – right (wt)	
	Bag fill total (wt)	