

# **ECONOMIC ANALYSIS OF ALTERNATIVE TILLAGE YIELDS: A MONTE CARLO ANALYSIS OF ARLINGTON FIELD TRIALS**

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# Outline

- **Summary of 1997-2007 Arlington Reduced Tillage Field Trials:**
  - **Average and Annual Relative Yield Variability.**
    - Reduced Tillage (Strip-Till (ST) and No-Till (NT) Yields Relative to Chisel (CH).
  - **Average and Annual Relative Cost of Production (COP).**
    - COP/bu Nets Out COP/acre and BU/acre Differences.
    - **Evaluated at 2007 WI Custom Hire Rates.**
- **Monte Carlo Simulation of Annual Relative Costs of Production (COP).**
  - **Provides Probabilities(COP/bu<sub>Reduced Tillage</sub> < COP/bu<sub>Chisel</sub>)!!!**
- **Summary/Conclusions.**



**Alternative Tillage COP**

# 1997-2007 Arlington Research Station Reduced Tillage Field Trials

- Dick Wolkowski's Alternative Tillage Field Trial Data from the Arlington Research Station.
- Purpose: comparing yield differences under 3 tillage systems:
  - a traditional conservation tillage: fall chisel (CH),
  - an intermediate reduced tillage system: strip till (ST)
  - an “extreme” reduced tillage system: no-till (NT) without row cleaners.
- Across 3 cropping systems:
  - continuous corn (CC),
  - corn following soybeans (SBC),
  - soybeans following corn (CSB).



Alternative Tillage COP

# Annual and Average Relative Yields

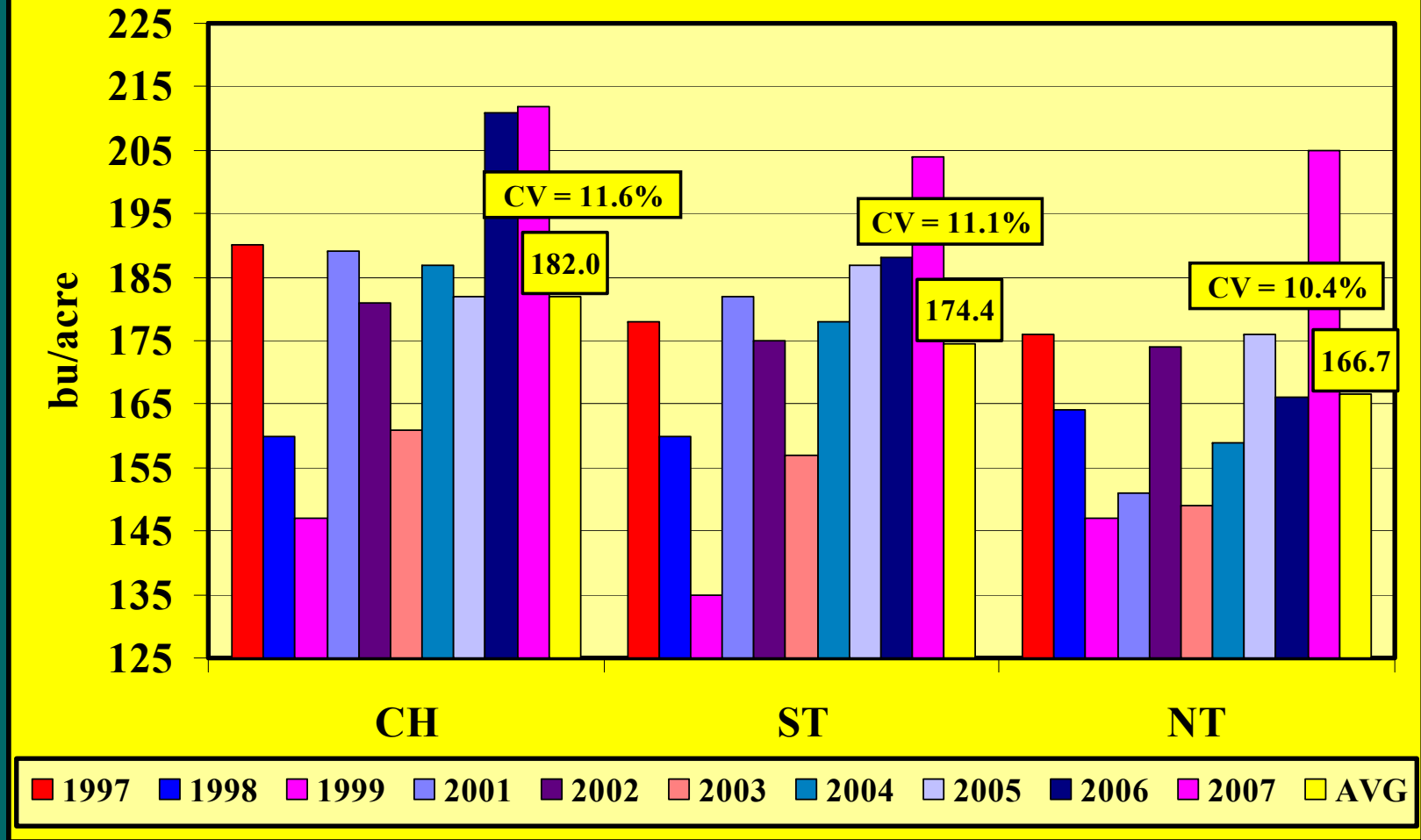
- Highlights relative yields of reduced tillage systems compared to CH (base tillage).
- **Clearly, some years are better/worse for these tillages/rotations than others.**
- **Clearly, some tillage/rotation yields are more variable than others.**
  - **A crucial dimension of the yield/production risk.**
  - **Essential dimension of the economic evaluation of alternative farming systems.**



**Alternative Tillage COP**

# Annual and Average Yield Variability

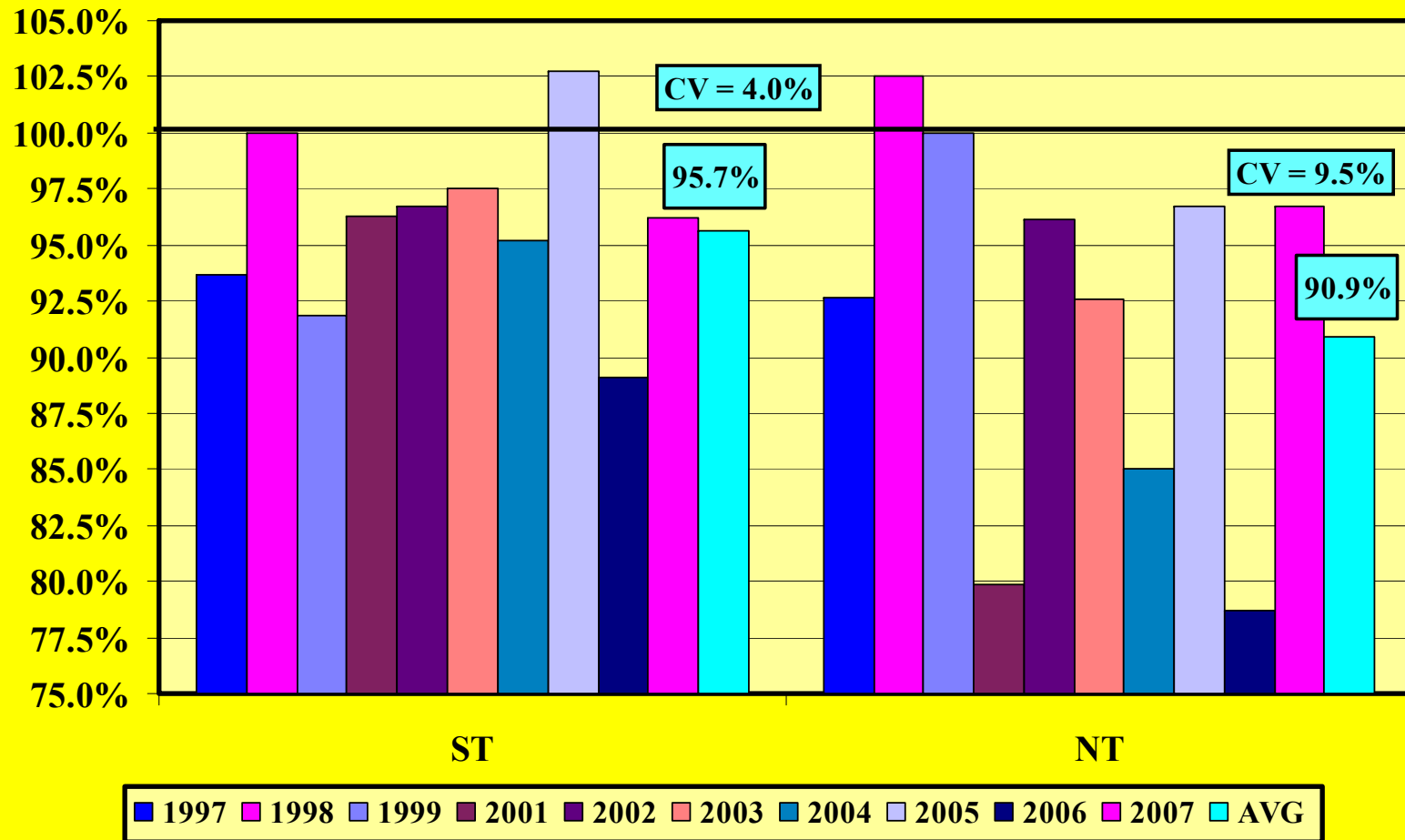
## 1997-2007 Arlington Tillage Trials: CC



Alternative Tillage COP

# Annual and Average Relative Yield Variability

1997-2007 Arlington Tillage Trials:  
Relative Yield Variability (Yields as % CH): CC



Alternative Tillage COP

# Annual and Average Relative Yields: CC

- CC Yields:

- **Some (noisy) increasing yield trends.**
- **On Average: CH (182) > ST (174) > NT (167).**
  - **Variability (CV): CH (11.6%) > ST (11.1%) > NT (10.4%).**
- **ST > CH yield in 2 of 10 years (98, 05).**
- **NT > CH yield in 2 of 10 years (98, 99).**
- **1999 = worst, 2007 = best year (all tillages).**

- CC Relative Yields:

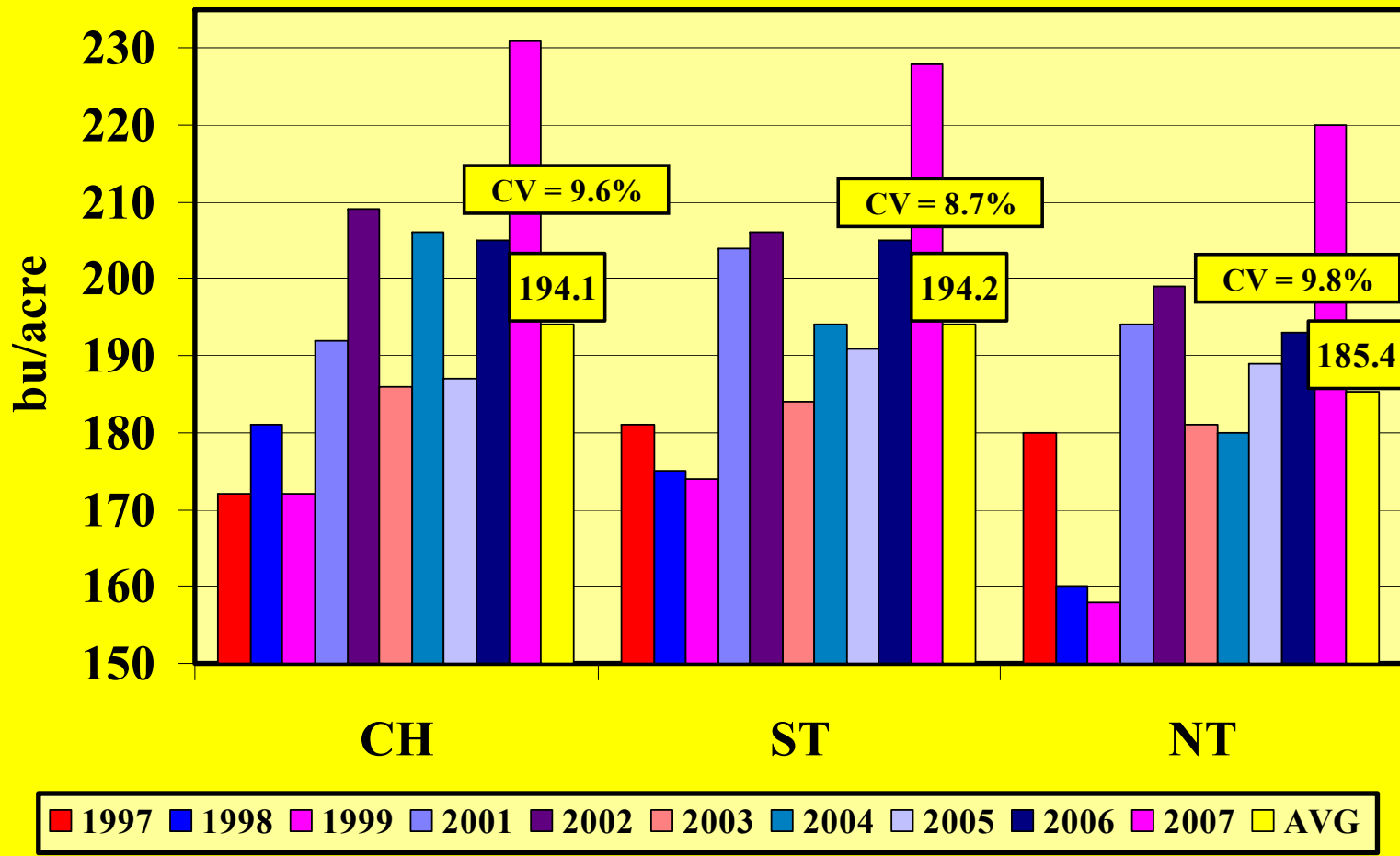
- **On Average: ST (95.7%) > NT (90.9%).**
- **2001 and 2006 = worst NT relative yields.**
- **NT has >2X more relative yield variability than ST:**
  - **Coefficient of variation: 9.5 versus 4.0.**
  - **High residue situation for NT (with no row cleaners)!!!**



**Alternative Tillage COP**

# Annual and Average Yield Variability

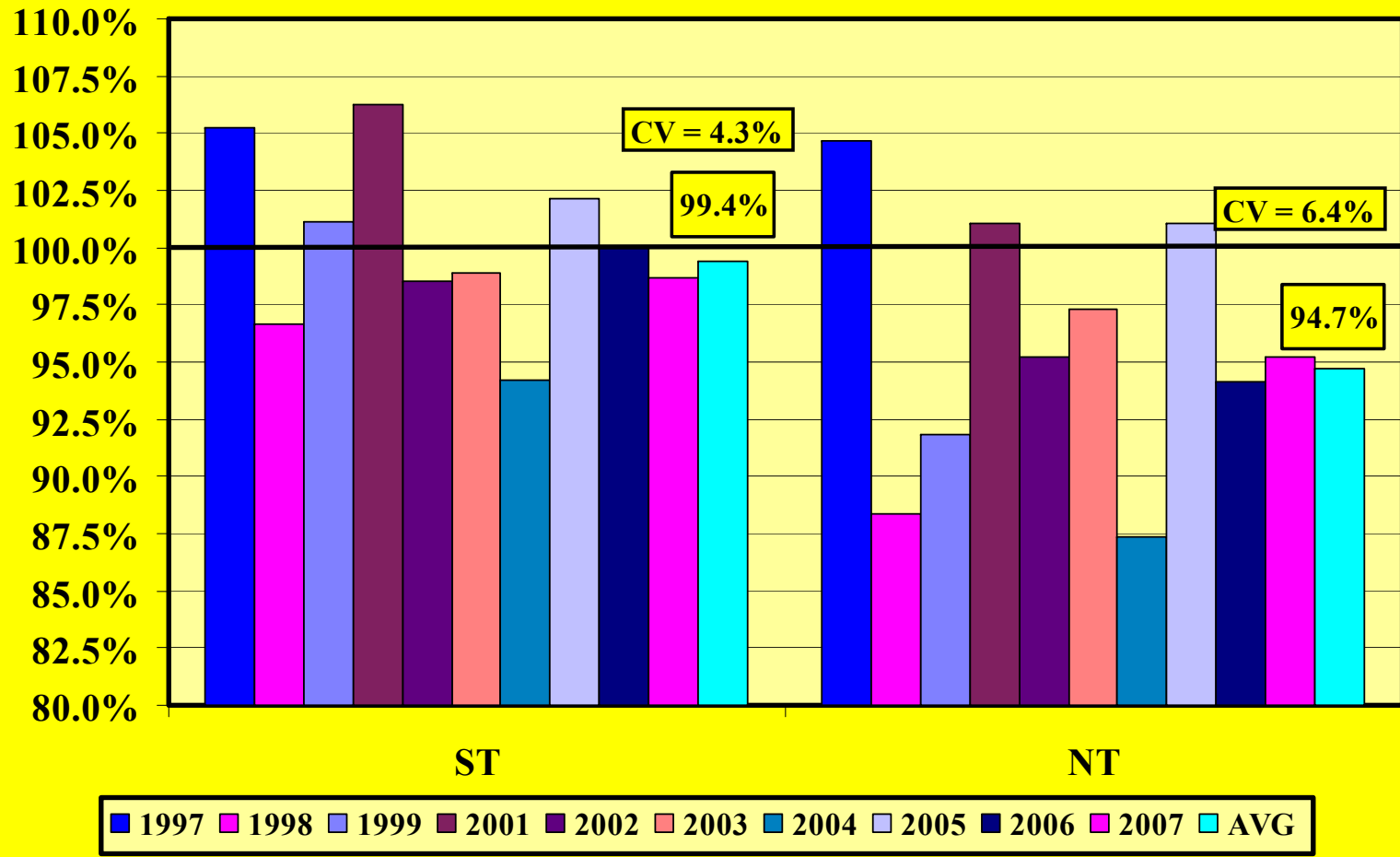
## 1997-2007 Arlington Tillage Trials: SBC



Alternative Tillage COP

# Annual and Average Relative Yield Variability

1997-2008 Arlington Tillage Trials:  
Relative Yield Variability (Yields as % CH): SBC



Alternative Tillage COP

# Annual and Average Relative Yields: SBC

- SBC Yields:

- **Some (noisy) increasing yield trends.**
- **On Average: CH (194.1)  $\approx$  ST (194.2) > NT (185.4).**
  - **Variability (CV): CH (9.6%) > ST (8.7%) > NT (9.8%).**
- **ST > CH yield in 5 of 10 years (98, 05).**
- **NT > CH yield in 3 of 10 years (98, 99).**
  - **2007 = best year (all tillages)!!!**

- SBC Relative Yields:

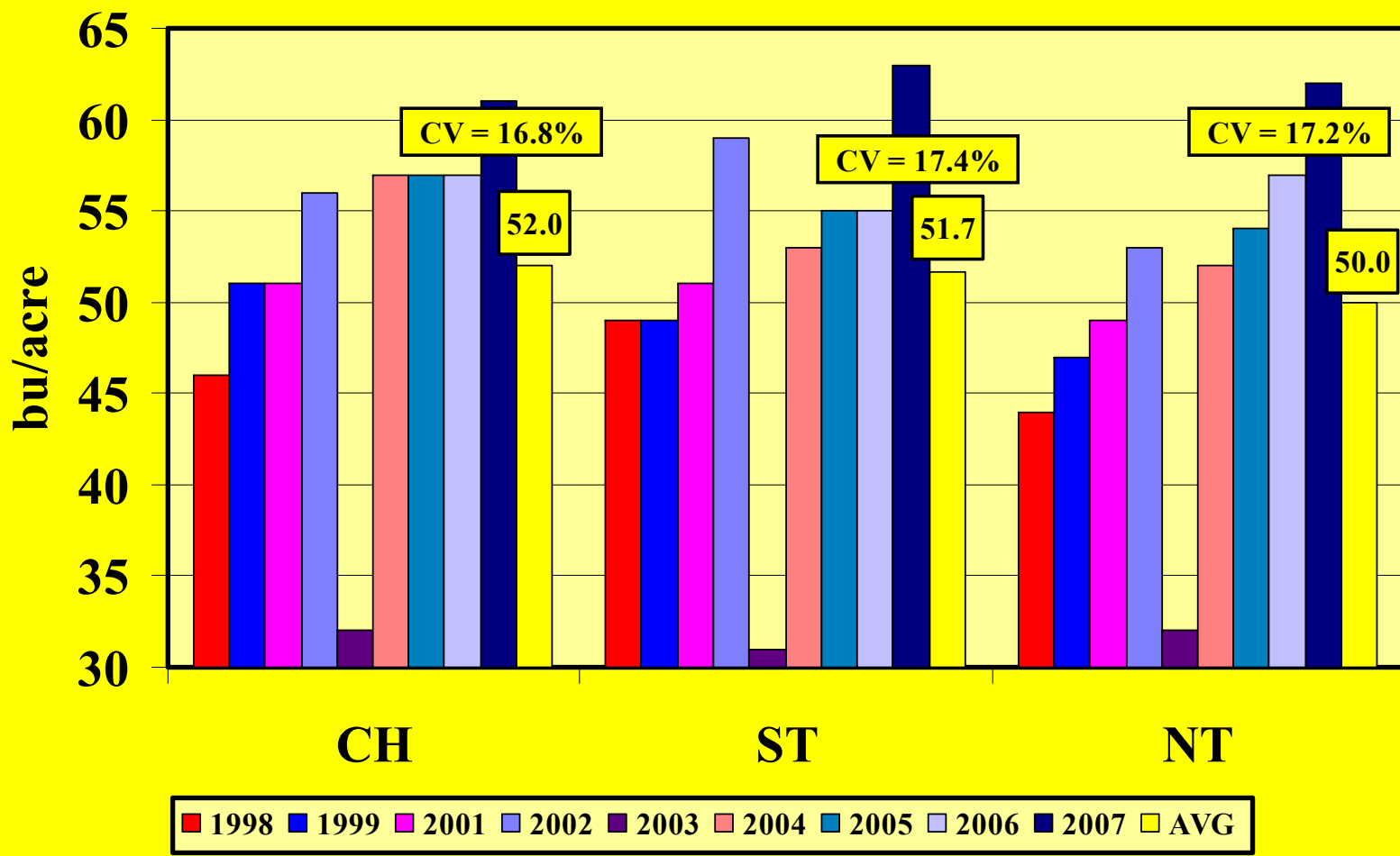
- **On Average: ST (99.4%) > NT (94.7%).**
- **1998 (NT) and 2004 (ST/NT) = worst relative yields.**
- **NT has 50% more relative yield variability than ST:**
  - **Coefficients of variation: 6.4 versus 4.3.**
  - **Lower residue situation than CC!!!**



**Alternative Tillage COP**

# Annual and Average Relative Yield Variability

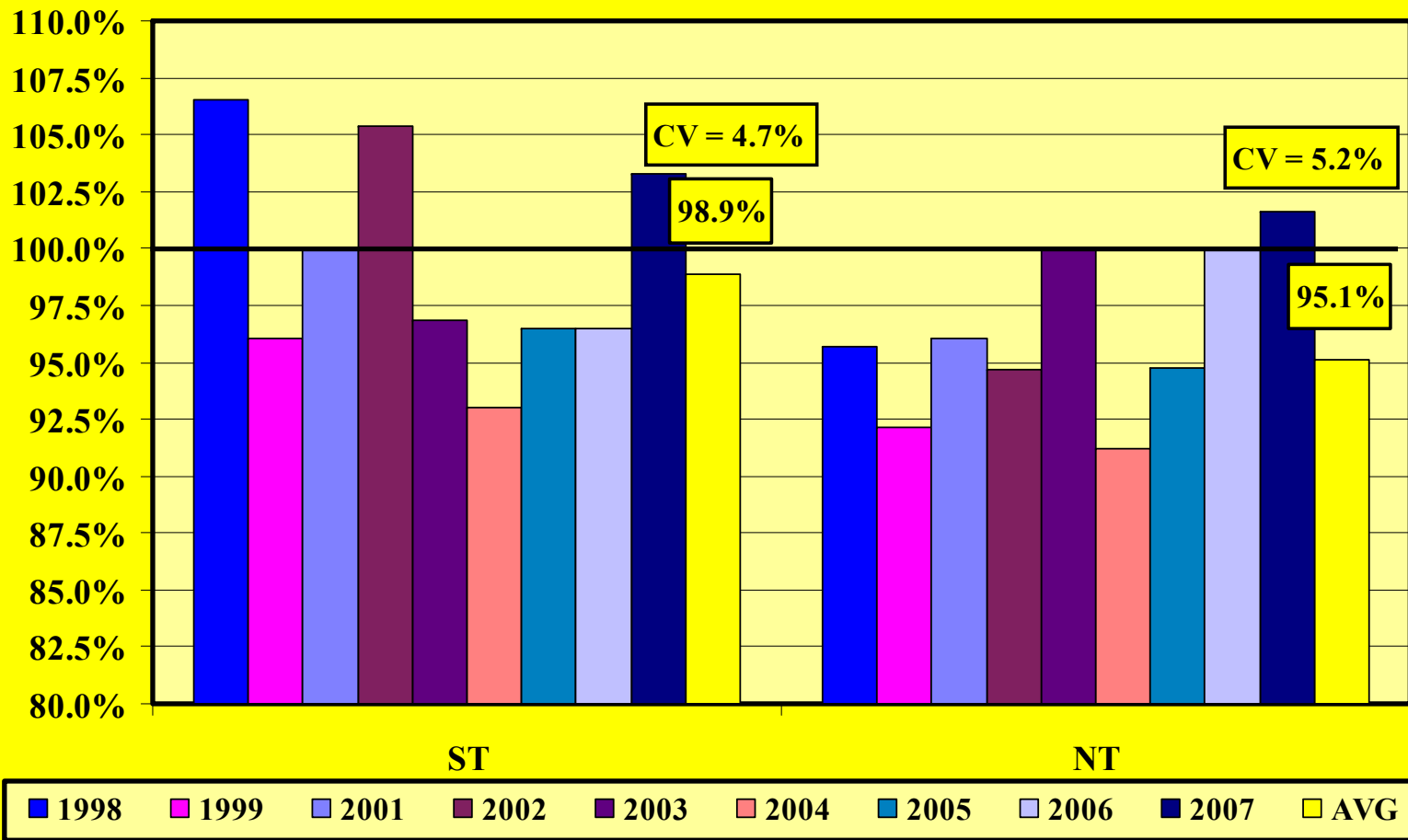
## 1997-2008 Arlington Tillage Trials: CSB



Alternative Tillage COP

# Annual and Average Relative Yield Variability

1997-2008 Arlington Tillage Trials:  
Relative Yield Variability (Yields as % CH): CSB



Alternative Tillage COP

# Annual and Average Relative Yields: CSB

- CSB Yields:

- Very strong increasing yield trends!!!
- On Average: CH (52)  $\approx$  ST (51.7)  $\approx$  NT (50).
  - **Variability (CV):** CH (16.8%) > ST (17.4%) > NT (17.2%).
- ST > CH yield in **4 of 9 years** (98, 01, 02, 07).
- NT > CH yield in **3 of 9 years** (03, 06, 07).
- **2003 = worst year (all tillages).**

- CSB Relative Yields:

- On Average: ST (98.9%) > NT (95.1%).
- **2004 = worst ST and NT relative yields.**
- NT has  $\sim$ 15% more relative yield variability than ST:
  - **Coefficient of variation: 5.2 versus 4.7.**
  - **NT soybeans less variable than corn.**



**Alternative Tillage COP**

# Annual and Average Relative Cost of Production (COP)

- Generally, less tillage incurs lower costs/acre due to lower labor, machinery, and fuel expenses using the same or fewer trips across the fields with equipment requiring less horsepower.
- However, these lower costs/acre can be offset by lower yields/acre due to reduced tillage systems as found in the Arlington field trials.



Alternative Tillage COP

# Annual and Average Relative Cost of Production (COP)

- Comparison of COP/bu corrects for the trade-off in lower COP/acre versus lower yields/acre.
- **If cost reductions are sufficient to offset lower yields, then potential economic gains (lower COP/bu) due to reduced tillage systems will further complement their environmental benefits (reduced soil and nutrient loss; improved soil quality, structure and tilth, organic matter, carbon sequestration, etc).**



Alternative Tillage COP

# 2007 COP/Acre: Corn

Appendix Table 1. Corn Costs Per Acre @ 2007 WI Custom Hire Rates.

Implement	Nitrogen Applied With Applicator				Nitrogen Applied With Planter			
	No-Till	Planter Strip Till	Pre-Strip Till	Chisel	No-Till	Planter Strip Till	Pre-Strip Till	Chisel
Chisel Plow				\$14.70				\$14.70
Field Cultivator				\$11.50				\$11.50
Strip Till Tool			\$15.00				\$15.00	
Dry Fertilizer Application	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Nitrogen Applicator	\$12.00	\$12.00		\$12.00				
Planter	\$16.10	\$16.10	\$15.80	\$15.80	\$16.10	\$16.10	\$15.80	\$15.80
Sprayer Pass I	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50
Sprayer Pass II	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50
Combining	\$26.40	\$26.40	\$26.40	\$26.40	\$26.40	\$26.40	\$26.40	\$26.40
<b>Machinery Costs Subtotal</b>	<b>\$74.50</b>	<b>\$74.50</b>	<b>\$77.20</b>	<b>\$100.40</b>	<b>\$62.50</b>	<b>\$62.50</b>	<b>\$77.20</b>	<b>\$88.40</b>
Nitrogen Fertilizer	\$87.75	\$87.75	\$87.75	\$87.75	\$128.25	\$128.25	\$128.25	\$128.25
P and K Fertilizer	\$65.70	\$65.70	\$65.70	\$65.70	\$65.70	\$65.70	\$65.70	\$65.70
Herbicide	\$35.00	\$35.00	\$35.00	\$35.00	\$35.00	\$35.00	\$35.00	\$35.00
Seed	\$75.00	\$75.00	\$75.00	\$75.00	\$75.00	\$75.00	\$75.00	\$75.00
<b>Variable Costs Subtotal</b>	<b>\$263.45</b>	<b>\$263.45</b>	<b>\$263.45</b>	<b>\$263.45</b>	<b>\$303.95</b>	<b>\$303.95</b>	<b>\$303.95</b>	<b>\$303.95</b>
<b>Land/Rental Costs</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>
<b>Total Costs: CORN</b>	<b>\$437.95</b>	<b>\$437.95</b>	<b>\$440.65</b>	<b>\$463.85</b>	<b>\$466.45</b>	<b>\$466.45</b>	<b>\$481.15</b>	<b>\$492.35</b>
<b>Change from Chisel</b>	<b>-\$25.90</b>	<b>-\$25.90</b>	<b>-\$23.20</b>	<b>--</b>	<b>-\$25.90</b>	<b>-\$25.90</b>	<b>-\$11.20</b>	<b>--</b>
<b>Breakeven Cost/Yield Difference</b>	<b>-8.4</b>	<b>-8.4</b>	<b>-7.5</b>	<b>--</b>	<b>-7.9</b>	<b>-7.9</b>	<b>-3.4</b>	<b>--</b>
<b>Cost/Bushel (= Breakeven Price)</b>	<b>\$2.92</b>	<b>\$2.92</b>	<b>\$2.94</b>	<b>\$3.09</b>	<b>\$3.11</b>	<b>\$3.11</b>	<b>\$3.21</b>	<b>\$3.28</b>



**Alternative Tillage COP**

# 2007 COP/Acre: Soybeans

Appendix Table 2. Soybean Costs Per Acre @ 2007 WI Custom Hire Rates.

Implement	Nitrogen Applied With Applicator				Nitrogen Applied With Planter			
	No-Till	Planter Strip Till	Pre-Strip Till	Chisel	No-Till	Planter Strip Till	Pre-Strip Till	Chisel
Chisel Plow				\$14.70				\$14.70
Field Cultivator				\$11.50				\$11.50
Strip Till Tool			\$15.00				\$15.00	
Dry Fertilizer Application	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Planter	\$16.10	\$16.10	\$15.80	\$15.80	\$16.10	\$16.10	\$15.80	\$15.80
Sprayer Pass I	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50
Sprayer Pass II	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50	\$7.50
Combining	\$26.10	\$26.10	\$26.10	\$26.10	\$26.10	\$26.10	\$26.10	\$26.10
<b>Machinery Cost Subtotal</b>	<b>\$62.20</b>	<b>\$62.20</b>	<b>\$76.90</b>	<b>\$88.10</b>	<b>\$62.20</b>	<b>\$62.20</b>	<b>\$76.90</b>	<b>\$88.10</b>
P and K Fertilier	\$70.20	\$70.20	\$70.20	\$70.20	\$70.20	\$70.20	\$70.20	\$70.20
Herbicide	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00
Seed	\$50.00	\$50.00	\$50.00	\$50.00	\$50.00	\$50.00	\$50.00	\$50.00
<b>Variable Cost Subtotal</b>	<b>\$145.20</b>	<b>\$145.20</b>	<b>\$145.20</b>	<b>\$145.20</b>	<b>\$145.20</b>	<b>\$145.20</b>	<b>\$145.20</b>	<b>\$145.20</b>
<b>Land/Rental Cost</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>	<b>\$100.00</b>
<b>Total Costs: BEANS</b>	<b>\$307.40</b>	<b>\$307.40</b>	<b>\$322.10</b>	<b>\$333.30</b>	<b>\$307.40</b>	<b>\$307.40</b>	<b>\$322.10</b>	<b>\$333.30</b>
<b>Change from Chisel</b>	<b>-\$25.90</b>	<b>-\$25.90</b>	<b>-\$11.20</b>	<b>--</b>	<b>-\$25.90</b>	<b>-\$25.90</b>	<b>-\$11.20</b>	<b>--</b>
<b>Breakeven Cost/Yield Difference</b>	<b>-3.5</b>	<b>-3.5</b>	<b>-1.5</b>	<b>--</b>	<b>-3.5</b>	<b>-3.5</b>	<b>-1.5</b>	<b>--</b>
<b>Cost/Bushel (= Breakeven Price)</b>	<b>\$6.83</b>	<b>\$6.83</b>	<b>\$7.16</b>	<b>\$7.41</b>	<b>\$6.83</b>	<b>\$6.83</b>	<b>\$7.16</b>	<b>\$7.41</b>

**Alternative Tillage COP**

# 2007 COP/Acre: Summary

## • Corn:

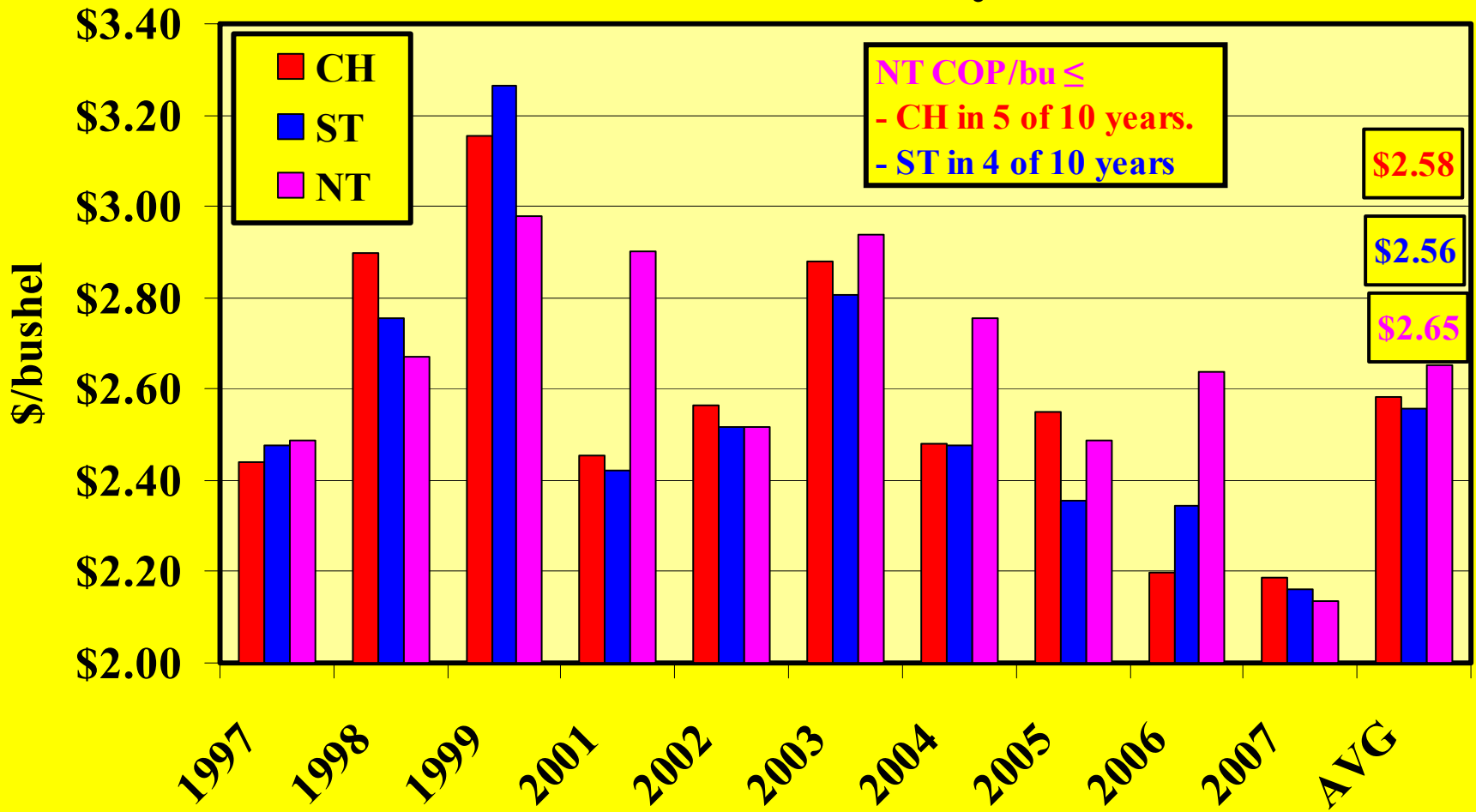
- Less tillage reduces COP/acre \$11.20-\$25.90/acre versus CH!!!
- Equivalent to 3.4 – 8.4 bu/acre @ assumed corn yield (150 bu/acre).
- That is, less tillage can “give up” this much yield to “break even” with CH COP.

## • Soybeans:

- Less tillage reduces COP/acre: \$11.20-\$25.90/acre versus CH.
- Equivalent to 1.5 – 3.5 bu/acre @ assumed soybean yield (45 bu/acre).
- That is, less tillage can “give up” this much yield to “break even” with CH COP.

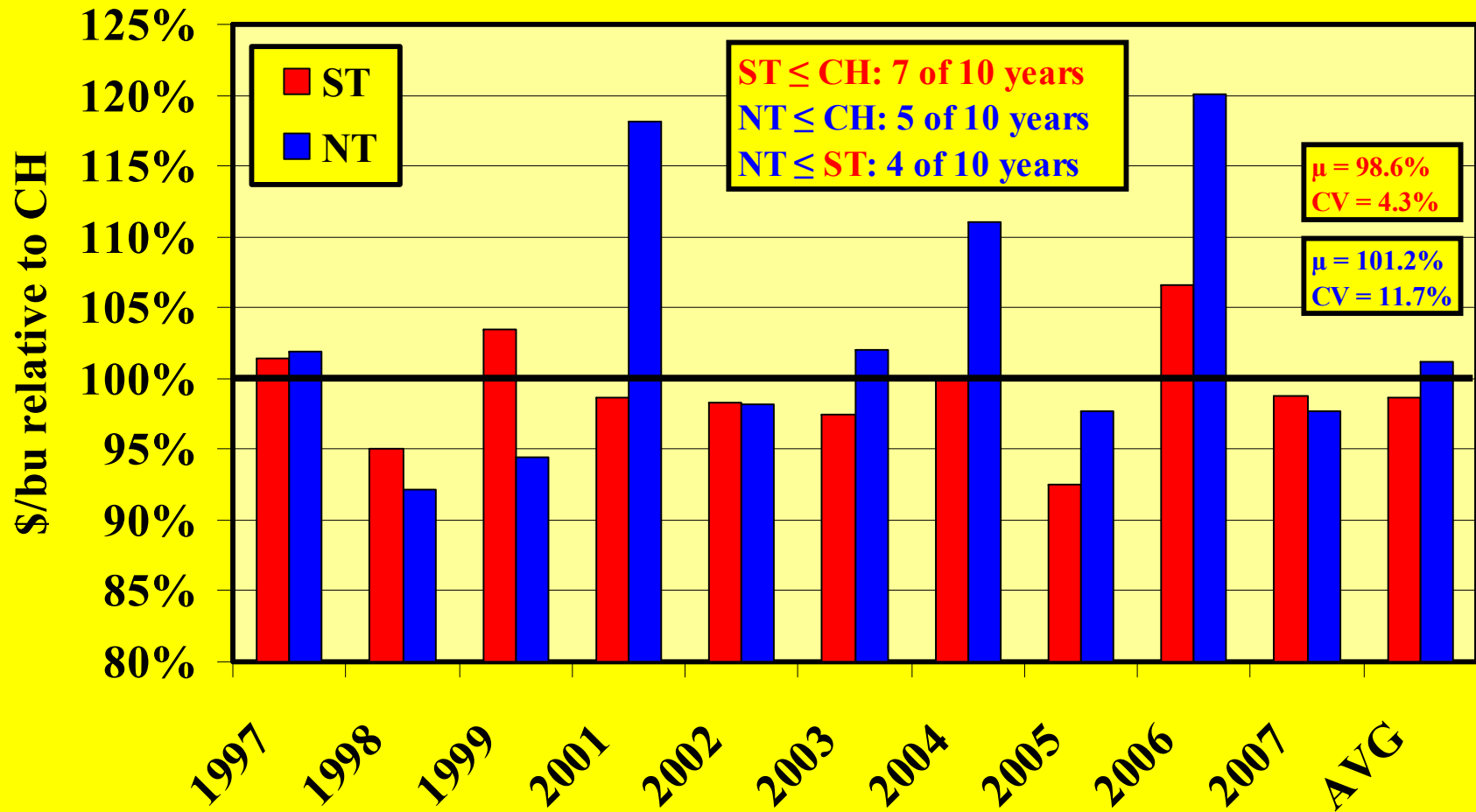
# 1997-2007 Arlington Tillage Trials: CC

## COP/bu Variability



Alternative Tillage COP

# 1997-2007 Arlington Tillage Trials: CC Relative (to CH) COP/bu



Alternative Tillage COP

# Annual and Average Relative COP/bu: CC

- CC COP/bu:

- On Average: ST (\$2.56) < CH (\$2.58) < NT (\$2.65).

- BUT:

- NT  $\leq$  CH COP/bu in 5 of 10 years!!!
- NT  $\leq$  ST COP/bu in 4 of 10 years!!!

- CC Relative COP/bu:

- On Average: ST (98.6) < NT (101.2%).

- ST  $\leq$  CH: 7 of 10 years.

- NT  $\leq$  CH: 5 of 10 years!!!

- NT  $\leq$  ST: 4 of 10 years!!!

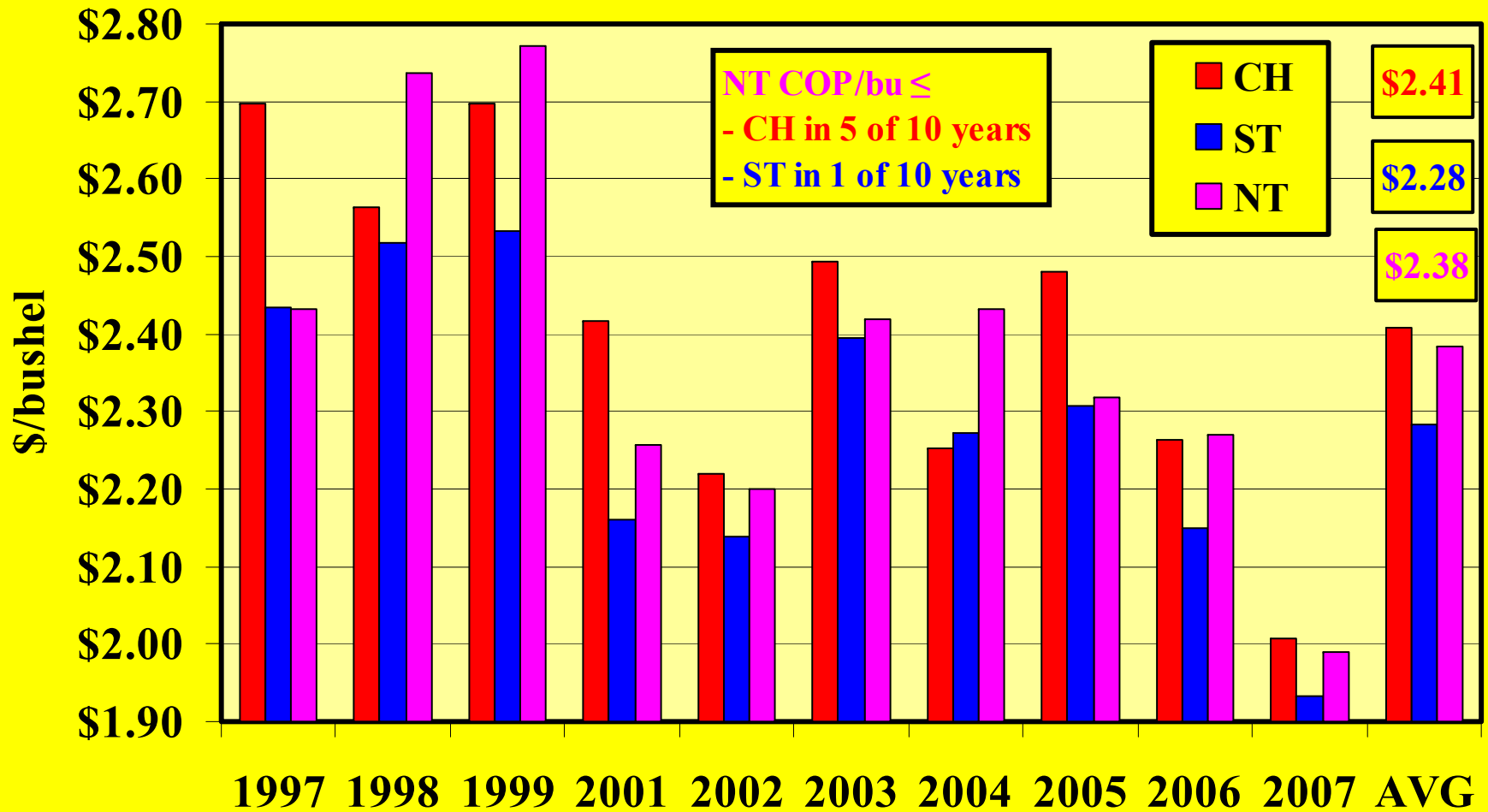
- NT has >2X more relative yield variability than ST:

- Coefficient of variation: 11.7% versus 4.3%.
- High residue situation.



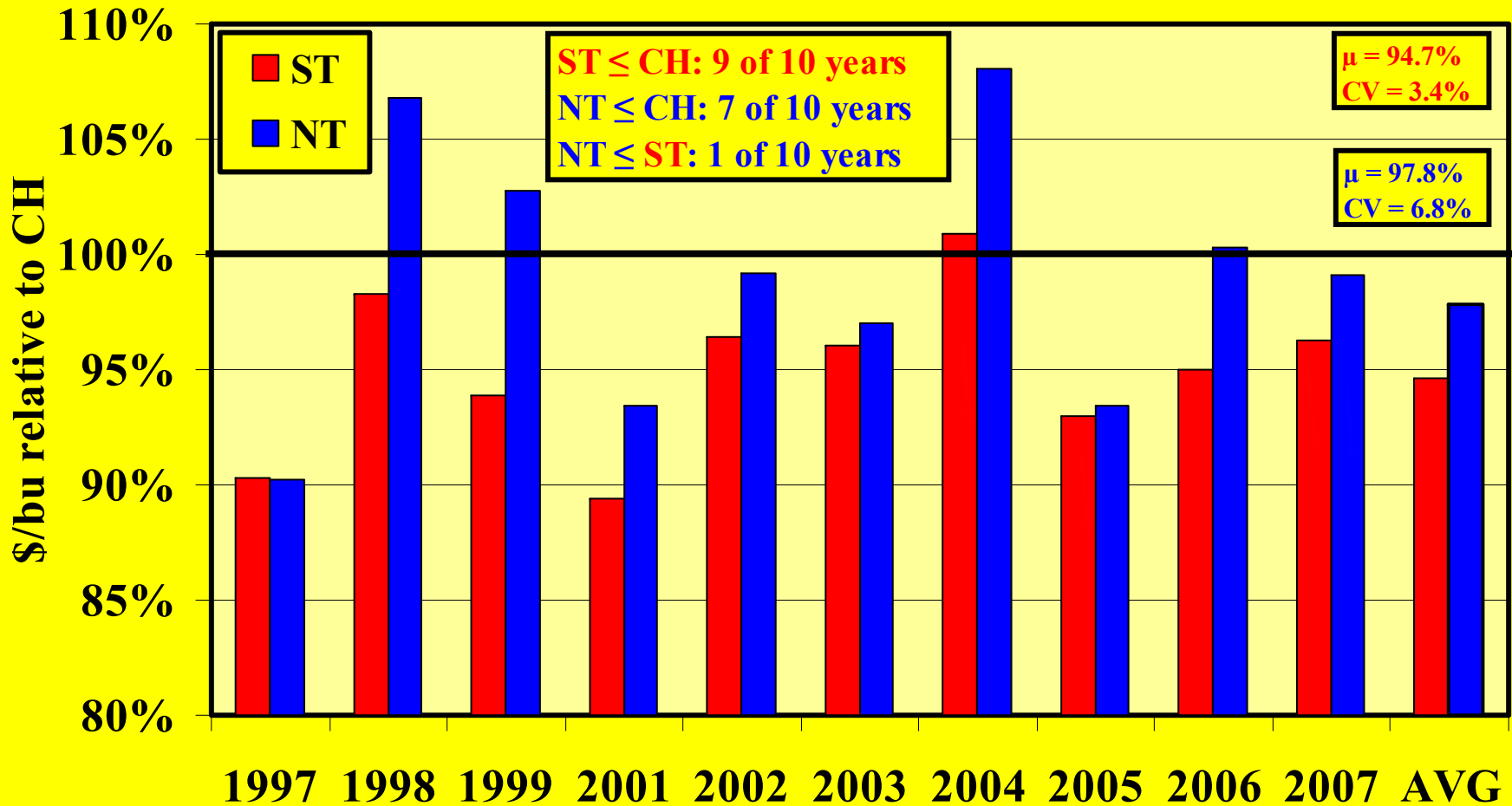
Alternative Tillage COP

# 1997-2007 Arlington Tillage Trials: SBC COP/bu Variability



Alternative Tillage COP

# 1997-2007 Arlington Tillage Trials: SBC Relative (to CH) COP/bu



**Alternative Tillage COP**

# Annual and Average Relative COP/bu: SBC

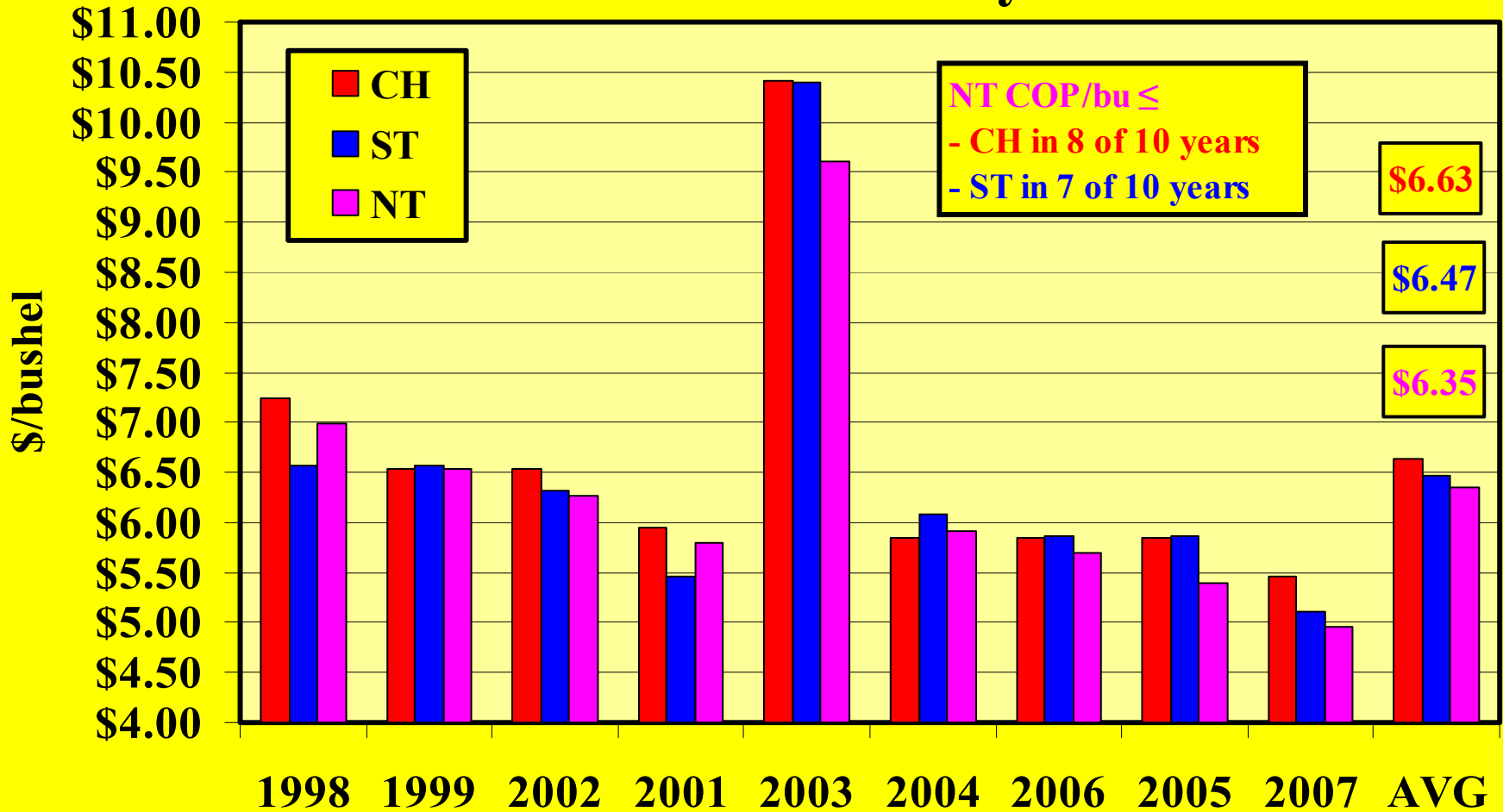
- SBC COP/bu:
  - On Average: ST (\$2.28) < NT (\$2.38) < CH (\$2.41).
  - NT  $\leq$  CH COP/bu in 5 of 10 years.
  - NT  $\leq$  ST COP/bu in 1 of 10 years.
- SBC Relative COP/bu:
  - On Average: ST (94.7) < NT (97.8%).
  - ST  $\leq$  CH: 9 of 10 years
  - NT  $\leq$  CH: 7 of 10 years
  - NT  $\leq$  ST: 1 of 10 years
  - NT has 2X more relative yield variability than ST:
    - Coefficient of variation: 6.8% versus 3.4%.



Alternative Tillage COP

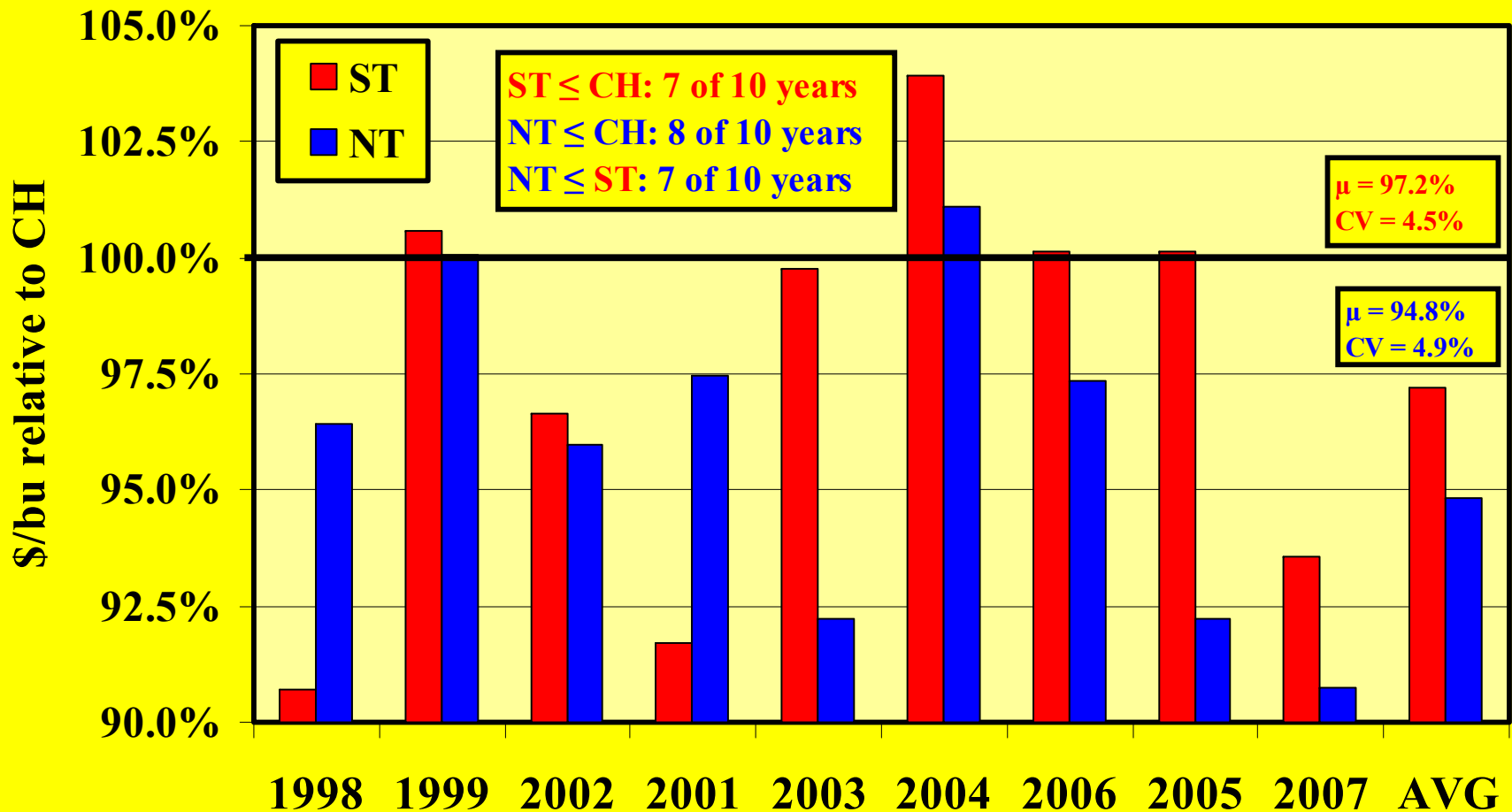
# 1997-2007 Arlington Tillage Trials: CSB

## COP/bu Variability



**Alternative Tillage COP**

# 1997-2007 Arlington Tillage Trials: CSB Relative (to CH) COP/bu



**Alternative Tillage COP**

# Annual and Average Relative COP/bu: SBC

- CC COP/bu:
  - **On Average: NT (\$6.35) < ST (\$6.47) < CH (\$6.63).**
  - NT  $\leq$  CH COP/bu in 8 of 10 years.
  - NT  $\leq$  ST COP/bu in 7 of 10 years.
- CC Relative COP/bu:
  - **On Average: NT (94.8%) < ST (97.2%).**
  - ST  $\leq$  CH: 7 of 10 years.
  - NT  $\leq$  CH: 8 of 10 years.
  - NT  $\leq$  ST: 7 of 10 years.
  - **NT has ~10% more relative yield variability than ST:**
    - Coefficient of variation: 4.9% versus 4.5%.
    - SB less relative yield variability than corn rotations.



**Alternative Tillage COP**

# Monte Carlo Simulation of Annual Relative Costs of Production (COP/bu).

- Provides Probability that Reduced Tillage < Chisel:
  - Probabilities > 50% imply more likely than not.
  - High Probability that ST & NT < CH Yield (except SBC ST).
  - High Probability ST COP/bu < CH for SBC and CSB (NT for CSB).
  - Low Probability NT COP/bu < CH for CC (> 50% for SBC).

Table 7. Comparison of Probability ST or NT < CH.

		COP/bushel	
Crop/System	YIELD	N w/ App	N w/ Planter
<b>CC</b>			
ST	66.7%	54.7%	42.6%
NT	97.0%	22.7%	21.9%
<b>SBC</b>			
ST	49.6%	87.6%	69.6%
NT	76.3%	56.8%	56.1%
<b>CSB</b>			
ST	55.3%	71.3%	
NT	75.4%	76.4%	

Alternative Tillage COP

# Summary/Conclusions

- Annual relative yield and COP/bu variability are important to consider when comparing tillage/rotation systems.
  - **Measures of relative (to CH) production and/or COP risk!!!**
- Reduced tillage systems can provide improved economic (COP/bu) as well as environmental (reduced soil and nutrient loss) performance.
  - **WI Ag must look for these WIN-WIN situations !!!**



**Alternative Tillage COP**

# Summary/Conclusions: NT

- These NT trials likely reflect “early adoption” and very conservative (no row cleaners) performance -- prior to a “mature” (soils and management) NT system.
- Even under this situation, NT COP/bu is competitive to CH in all rotations except CC.
- **AND, the superior COP tillage for CSB rotation.**



Alternative Tillage COP

# Summary/Conclusions: NT

- Results indicate that NT relative yield variability decreases dramatically with decreased crop residue: CC to SBC to CSB.
  - Improved NT residue management systems may allow NT to produce comparable yields to, and lower COP than, ST.
  - If residue issues are adequately addressed, all three systems should be competitive in yield with NT having the lowest COP/bu as well as superior environmental performance.



# Summary/Conclusions: ST

- Lower ST relative (to CH) yields and yield variability compared to NT in these Arlington field trials suggest that ST holds considerable promise as a transitional reduced tillage system.
  - Hybrid System: best of CH and NT.
  - Less management intensive than NT.
  - On average, outperforms CH and NT COP/bu under all rotations evaluated (except NT under CSB).
  - NOTE: With better residue management, NT may perform similarly to ST !!!



**Alternative Tillage COP**