Long-term Effects of Four Cropping Systems on Corn Grain Yields

Kulbhushan Grover, Heather Karsten, Greg Roth and Marvin Risius

Department of Crop and Soil Sciences, The Pennsylvania State University, University Park, PA 16802


Aerial view of the long-term study

Rationale

- Many long-term studies evaluate cropping systems by only comparing mean crop yields and overlook year-to-year yield variability which could be highly significant.
- Yield stability analysis is an effective technique to identify cropping systems that produce high and stable yields over years.

Hypotheses

- Corn grain yields in perennial and diverse cropping systems will
  - ✓ be higher and less variable
  - ✓ increase more over time
  - ✓ decline less in low-yielding years
  - ... as compared to annual systems in a long-term study.

Materials and Methods

- Study initiated in 1969 at the Penn State Russell E. Larson Agricultural Research Center, Rock Springs, PA.
- Split plot design with 4 blocks
  - Main plots: 3 fertility regimes to meet crop nutrient needs
    - •LF1 (Inorganic) •LF2 (N based manure) •LF3(P based manure)
  - Sub plots: 4 cropping systems

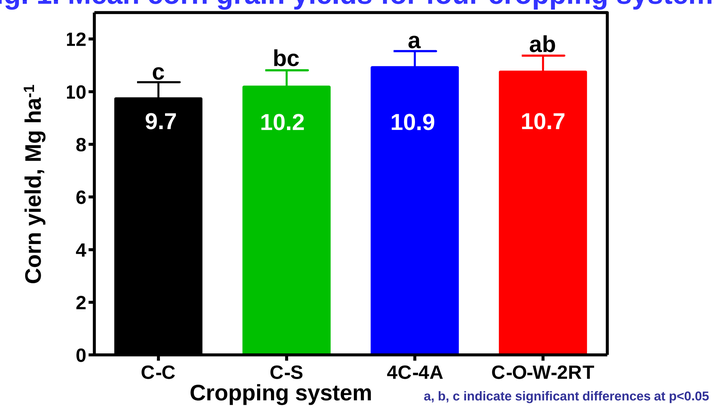
•C-C	Continuous corn
•C-S	Corn-soybean
•4C-4A	4 years of corn- 4 years of alfalfa
•C-O-W-2RT	Corn-oats-wheat-2 years of red clover+ timothy

Statistical analysis of corn yields (1990-2005)

- ANOVA using PROC MIXED of SAS
  - Fixed effects: Cropping systems, fertility regimes
  - Random effects: Blocks, years, interactions
  - Mean comparisons: Tukey's test ($p<0.05$)
- Time Trends and Stability Analysis using PROC MIXED of SAS
  - Linear regressions of corn yields on years & 'environment mean yields' (annual means across all treatments)
  - Slope comparisons: Pre-planned contrasts ($p<0.05$).
- ANOVA of Coefficients of Variation using PROC MIXED of SAS
  - Mean comparisons: Tukey's test ($p<0.05$)

Results and Discussion

Fig. 1. Mean corn grain yields for four cropping systems



- Mean corn yields were 12% and 7% higher in 1st year of 4C-4A than C-C & C-S respectively (Fig.1).
- Mean corn yields were 10% higher in C-O-W-2RT than C-C.

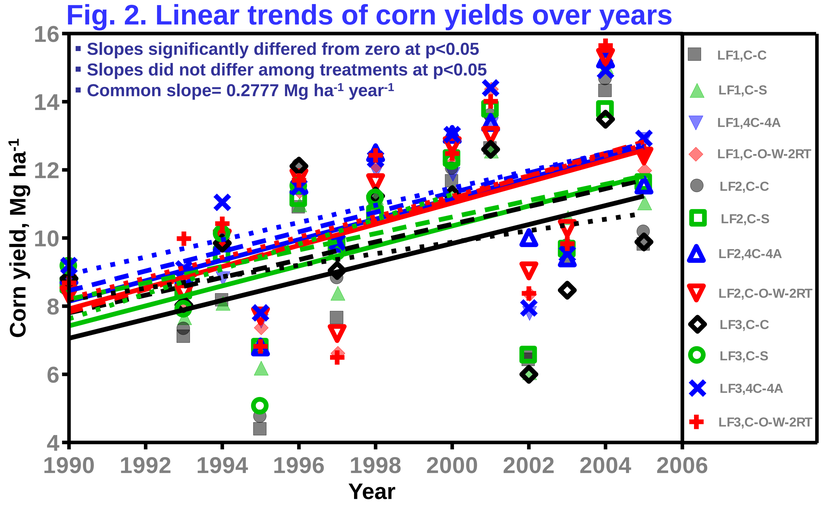
Table 1. Analysis of variance of corn yield with mixed procedure

Source of variation	df	Mean square
Block	3	1722425 NS
Fertility (LF)	2	4709611 NS
Block x LF	6	2608971 *
Cropping system (CT)	3	44443695 **
LF x CT	6	1089193 NS
Block x LF x CT	27	789780 NS
Year	14	234887706 ***
Year x LF	28	1661605 *
Year x CT	37	5042530 ***
Year x LF x CT	69	884759 **
Residual	444	555049

NS, not significant *, **, *** Significant at p<0.05, p<0.01. p<0.001 respectively.

- Corn yields differed among cropping systems and years (Table 1).
- Interactions of Year x LF, Year x CT & Year x LF x CT were significant.

Fig. 2. Linear trends of corn yields over years



- Corn yields increased similarly (0.28 Mg ha^{-1} year^{-1}) in all systems (Fig. 2).

Fig. 3. Stability analysis of corn yields in inorganic fertility (LF1)

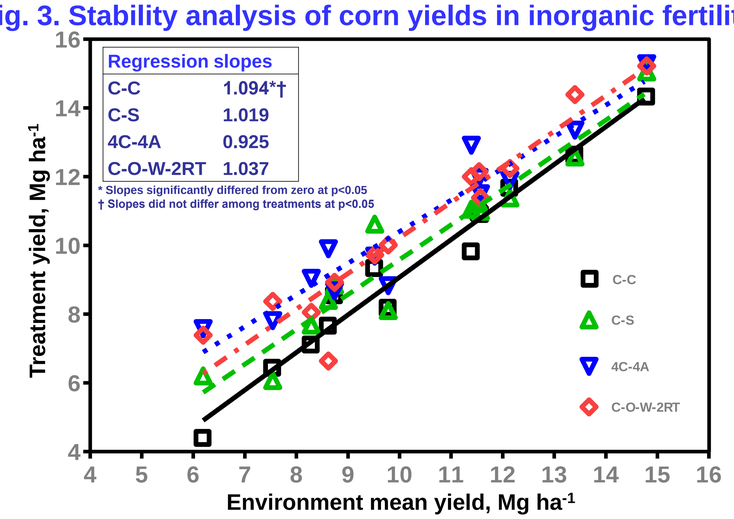
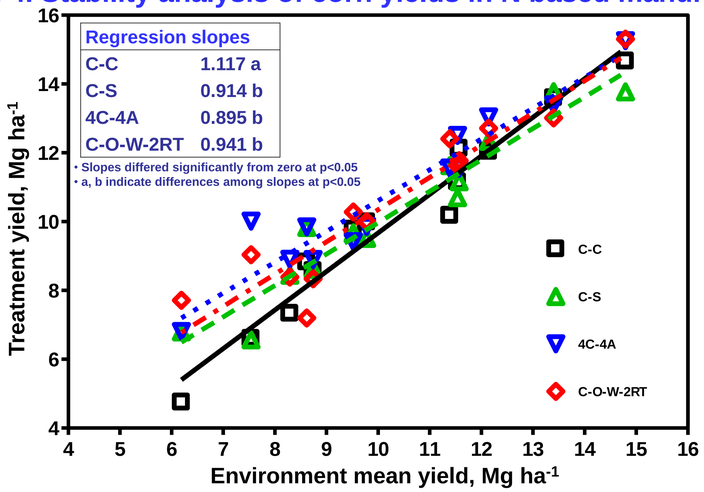


Fig. 4. Stability analysis of corn yields in N based manure (LF2)



- Stability of corn yields was similar among the four cropping systems in LF1 and LF3, indicated by similar slopes (Fig. 3).
- In LF2, however, slope of the C-C yields was >1, indicating lower stability than the other three cropping systems (Fig. 4). The C-C performance was poorer than the other three systems in low-yielding years.

Table 2. Means and ANOVA of C.V. of corn yields

Cropping system	df	Mean C.V. (%)
C-C		28.0 a
C-S		25.0 b
4C-4A		21.4 d
C-O-W-2RT		24.5 bc
	ANOVA	
Source of variation		
LF	2	NS
CT	3	***
LF x CT	6	NS

a, b, c indicate significant differences at p<0.05 NS, Not significantly different at p<0.05
***, Significant at p<0.001

- Corn yields were most variable in C-C followed by C-S & C-O-W- 2RT, and were least variable in 4C-4A (Table 2).

Conclusions

- ✓ Corn yields were 7-12% higher in the perennial and diverse systems (4C-4A & C-O-W-2RT) than the annual systems (C-C & C-S).
- ✓ Corn yield increases over years were similar (0.28 Mg ha^{-1} year^{-1}) in all the four cropping systems.
- ✓ Corn yields varied the most in the monoculture (C-C) and the least in the perennial system (4C-4A).
- ✓ In the N based manure fertility (LF2), the monoculture corn yields were less stable and were declined more in low-yielding years relative to the other three systems.

Acknowledgements

- Department of Crop and Soil Sciences, Pennsylvania State University.