WHAT DOES IT TAKE TO GROW CORN AT ITS YIELD POTENTIAL?

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Crop yield potential (Ymax)

What is it?

Theoretically achievable yield solely determined by genetic characteristics and climate (solar radiation, temperature).

How to measure it?

(a) Calculated from components of yield and radiation use efficiency.

(b) Measured in fully-controlled, small-scale experiment in which all biotic and abiotic stresses (water, nutrients, pests) are eliminated.

(b) Estimated by crop simulation models.

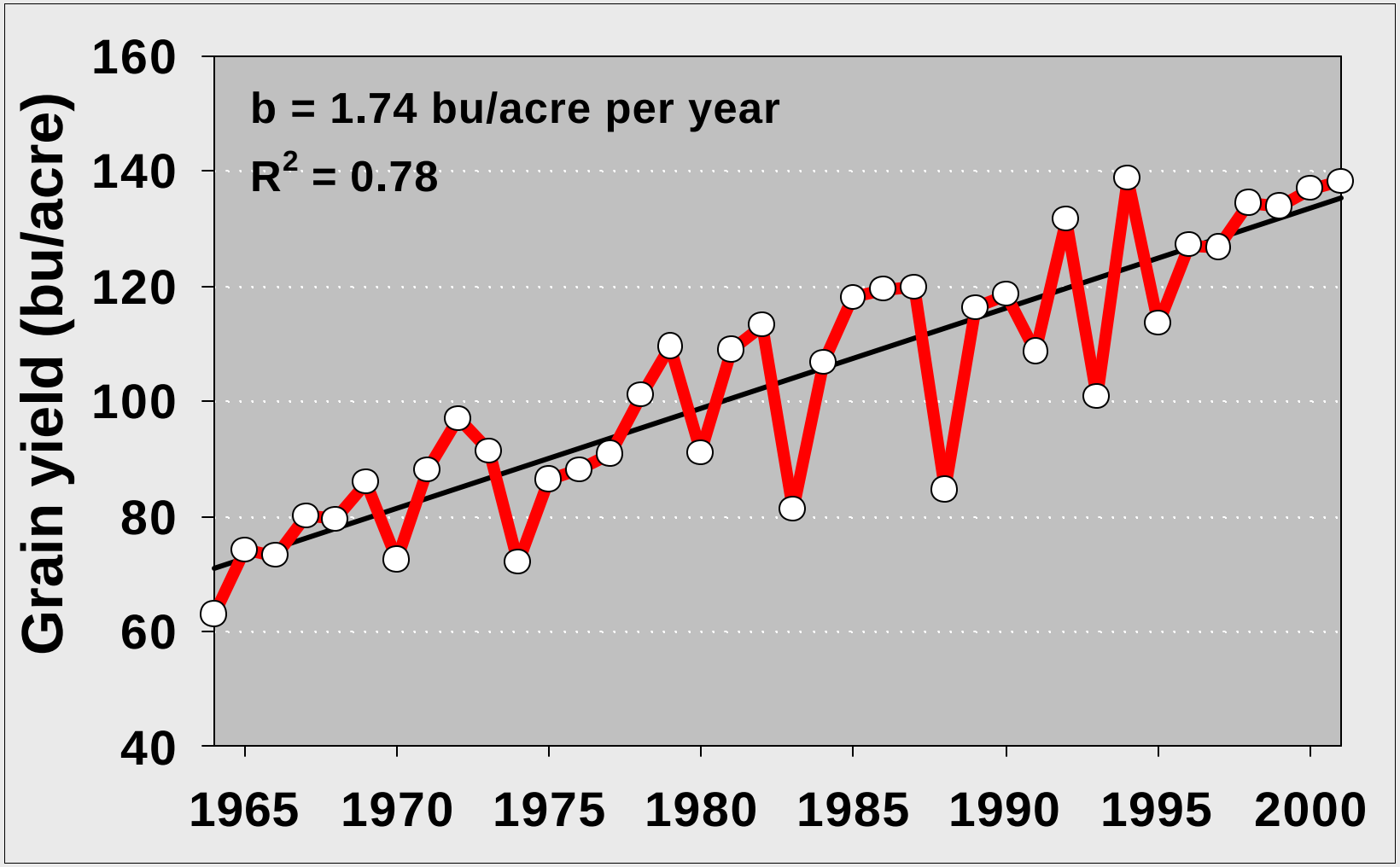
How to increase & utilize it?

(a) Genetics: breeding/germplasm improvement

(b) Management: optimization of planting date in relation to variation in Ymax that is due to the seasonal pattern of radiation and temperature

(c) Management: minimize abiotic/biotic stresses and crop loss

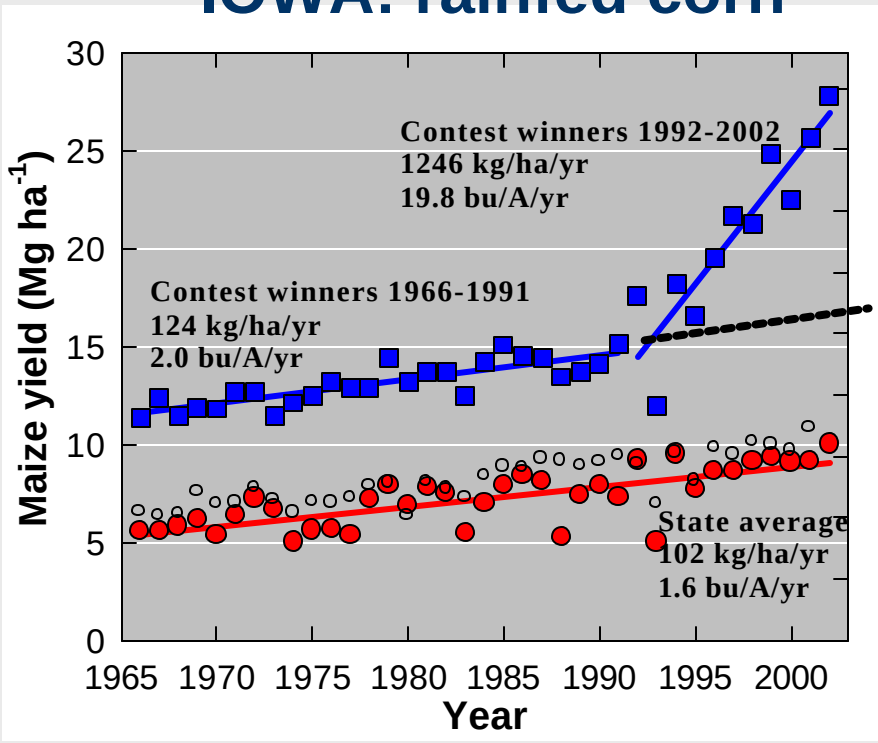
U.S. Corn Yields 1964 - 2001



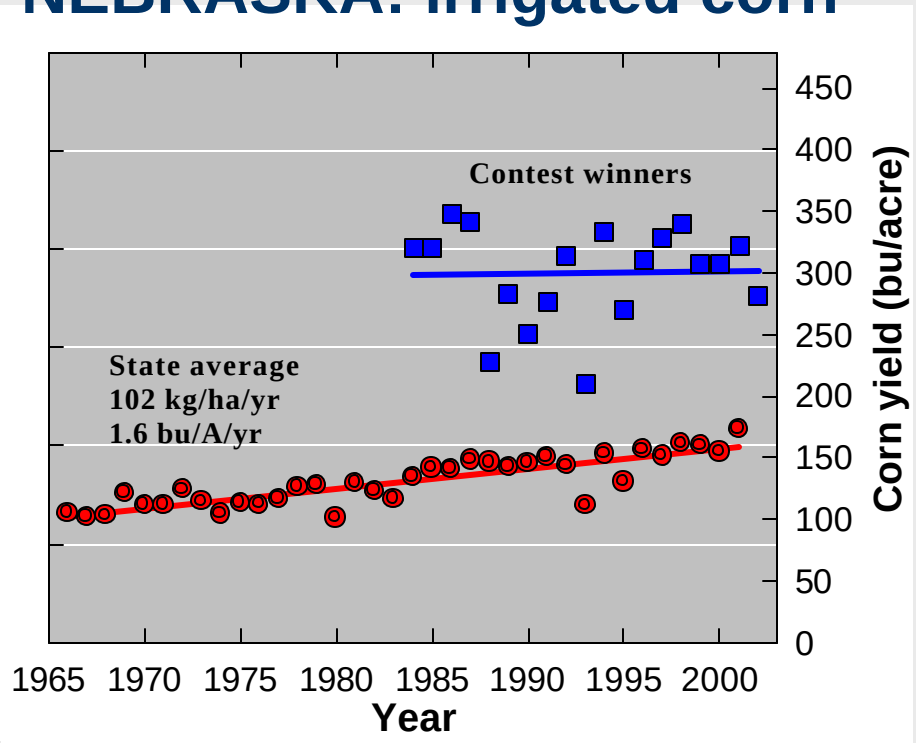
Source: Annual USDA cropping practices surveys of >2000 farms

Corn Yield Trends in Iowa and Nebraska

IOWA: rainfed corn



NEBRASKA: irrigated corn



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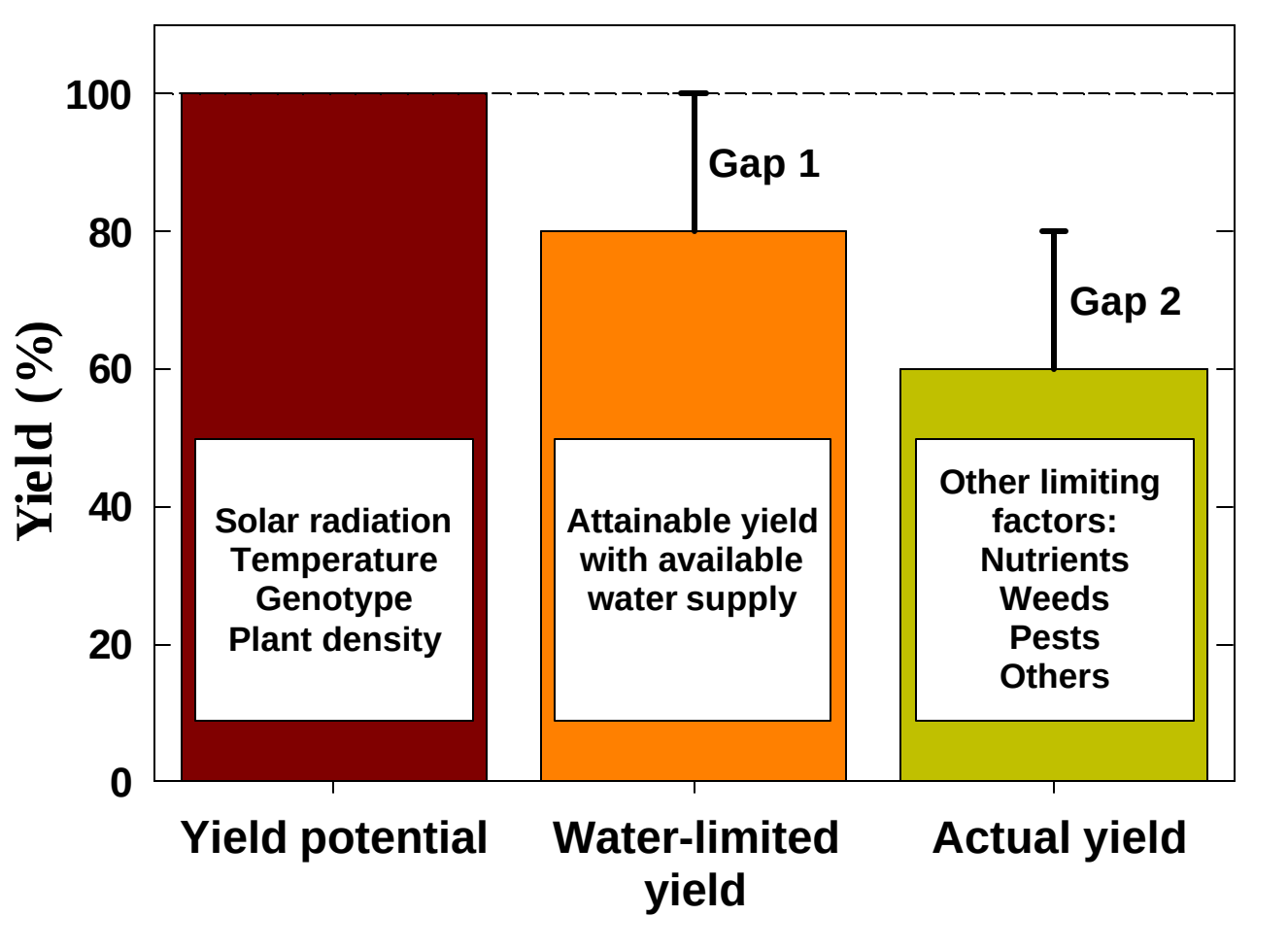
Yield potential and yield gaps



To achieve yield potential of an environment:

- Utilize the entire growing season

  (= optimal planting date and variety choice)
- Optimize plant population
- Grow the crop with minimal possible abiotic and biotic stresses (nutrients, water, pests)

Ecological Intensification of Maize-based Cropping Systems

Timothy J. Arkebauer	Environmenal crop physiology
Kenneth G. Cassman	Crop physiology and plant nutrition
Rhae A. Drijber	Soil microbial ecology
Achim Dobermann	Soil fertility and plant nutrition
John L. Lindquist	Corn ecophysiology & modeling
John P. Markwell	Biochemistry
Lenis A. Nelson	Plant breeding and crop production
James E. Specht	Soybean genetics
Daniel T. Walters	Soil fertility, C sequestration
Haishun Yang	Soil and crop modeling

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Nebraska Corn Board, Nebraska Soybean Board, United Soybean Board

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Ecological Intensification of Maize-based Cropping Systems

- Understand the yield potential of corn and soybean and how it is affected by management.
- Develop a scientific basis for extrapolation to other locations based on understanding of the key yield-determining processes.
- Develop practical technologies for managing systems at 80-90% of the yield potential.
- Conduct integrated assessment of productivity, profitability, input use efficiency, energy balance, and environmental consequences.

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EI Lincoln, NE: Treatments

Crop rotation (main plots)

CC	Continuous corn
CS	Corn – Soybean (corn in odd years)
SC	Soybean – Corn (corn in even years)

Plant Population (subplots)

P1	Corn: 30k	28-31,000 plants/acre
P2	Corn: 37k	35-41,000 plants/acre
P3	Corn: 44k	38-47,000 plants/acre)

Management Intensity (sub-subplots)

M1	recommended fertilizer management based on soil testing. Maize: UNL recommendation for 200 bu/acre yield goal
M2	intensive management aimed at yields close to yield potential. Maize yield goal 300 bu/acre, higher NPK rates, micronutrients, N in 3-4 splits

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EI Lincoln, NE: Management

Soil: Kennebec silt loam
pH 5.2-6.0, 2.5-3.0% SOM, 60-70 ppm Bray-1 P, 300-400 ppm K

Lime: applied in fall 1999 and fall 2001 to increase pH to about 6.0-6.5

Irrigation:		
	1999-2000	surface drip tape
	2001-2002	sub-surface drip tape
	2003	sprinkler

Tillage:		
	1999-2002	fall disk & moldboard plow, spring field cultivator/disk
	2003	fall disk & mini-moldboard plow, spring field cultivato

Hybrids:		
	1999-2000	Pioneer 33A14
	2001-2002	Pioneer 33P67
	2003	Pioneer 31N28

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EI Lincoln, NE: Fertilizer Program

Continuous corn (CC):

CC - **M1**: 170 lb N/acre (190 kg/ha), no P, no K

CC - **M2**: 270 lb N/acre (300 kg/ha)*,

- 92 lb P_2O_5/acre (45 kg P/ha) and
- 92 lb K_2O/acre (85 kg K/ha)

Corn after soybean (CS):

CS - **M1**: 116 lb N/acre (130 kg/ha) , no P, no K

CS - **M2**: 219 lb N/acre (246 kg/ha) ,

- 92 lb P_2O_5/acre (45 kg P/ha) and
- 92 lb K_2O/acre (85 kg K/ha)

N splitting: M1: pre-plant & V6 M2: pre-plant, V6, V10, V12-VT

*CC-M2: includes fall application of about 45 lb N/acre as UAN (since 2001)

Average rates applied during 1999-2003

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EI Lincoln, NE: Yields

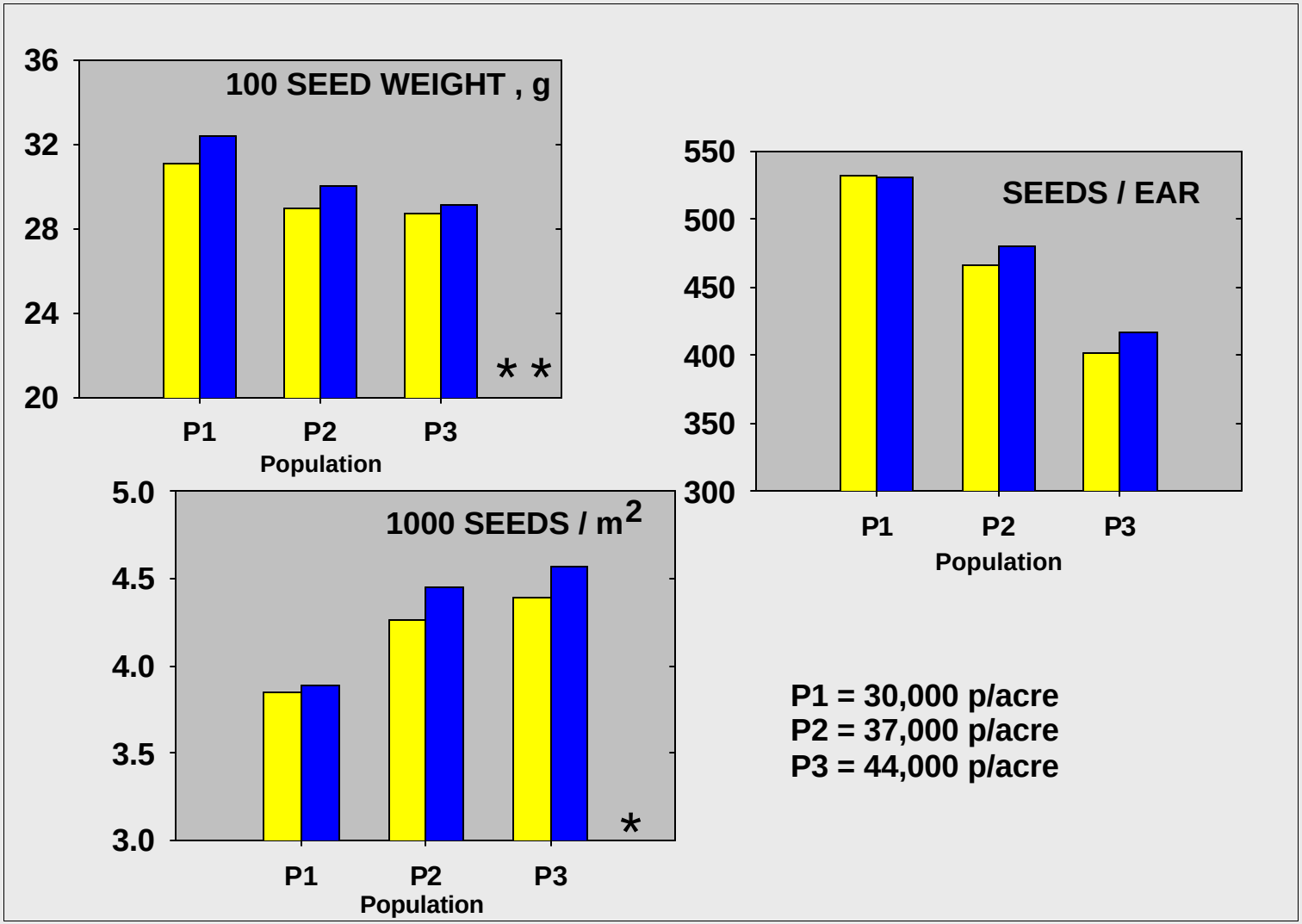
Density	Fertilizer	**Average**	**Grain yield 1999-2003 (bu/acre)**				
			1999	2000	2001	2002	2003
Continuous corn							
P1	M1	**217**		214	223	178	255
P2/3	M2	**247**		229	252	242	265
Corn after soybean							
P1	M1	**236**	219	225	230	221	268
P2/3	M2	**256**	257	248	249	243	285

M2 treatment with highest-yielding plant density:

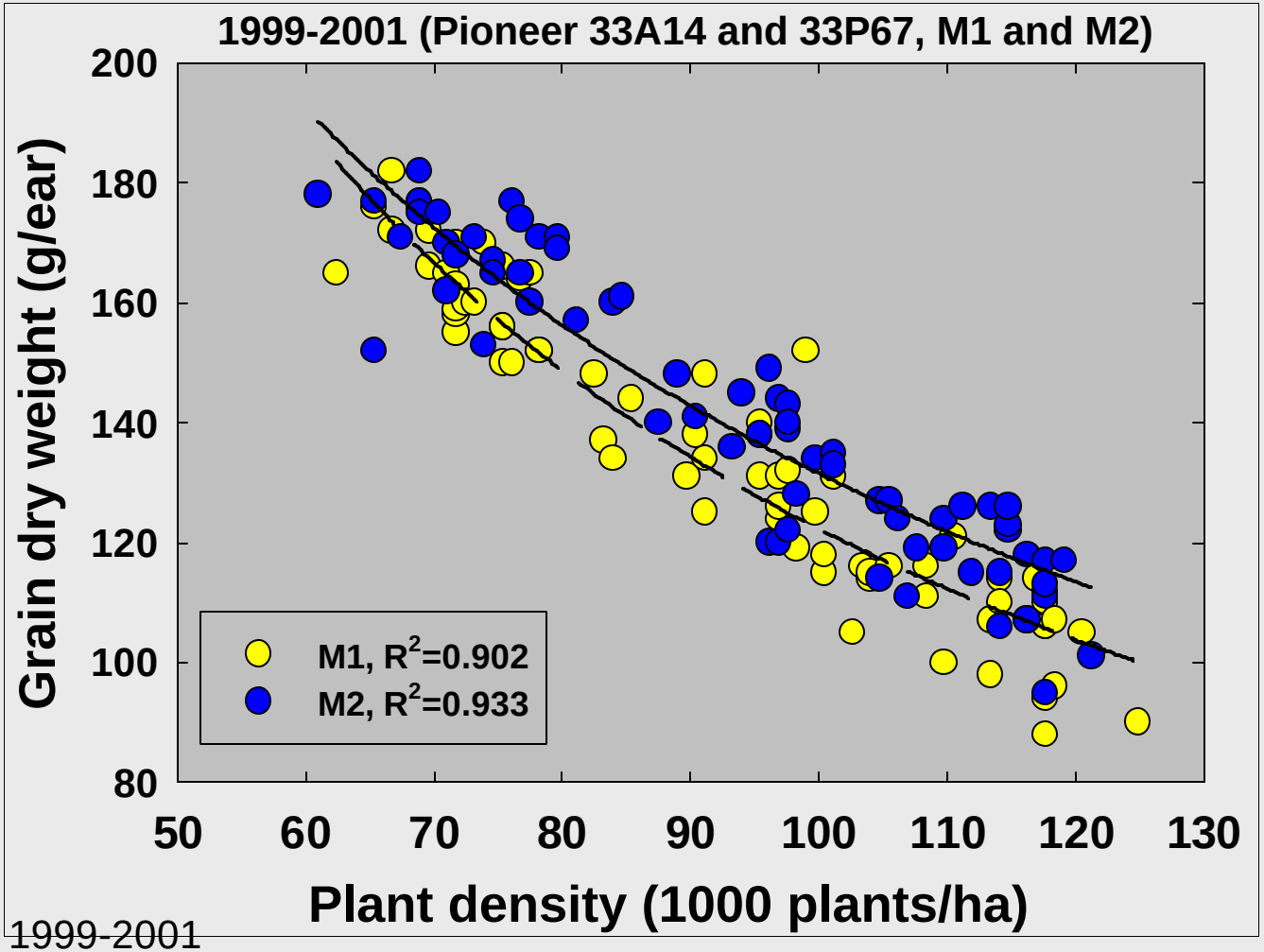
P2: 2000 and 2003

P3: 1999, 2001 and 2002

Seed Yield Components as Affected by Plant Density and Nutrient Management



Corn Grain Weight per Ear as Affected by Plant Density and Nutrient Management

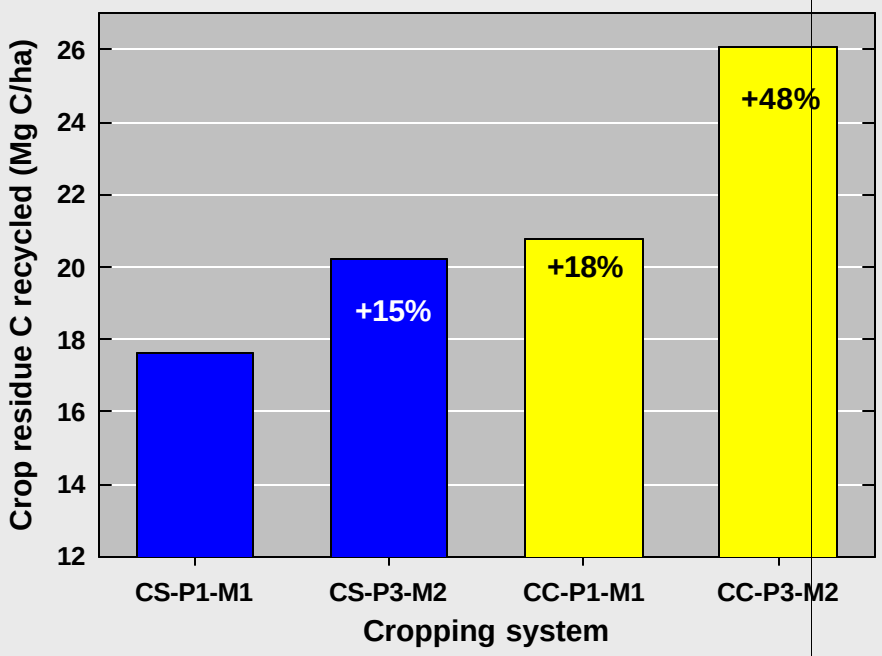


CS and CC, 1999-2001

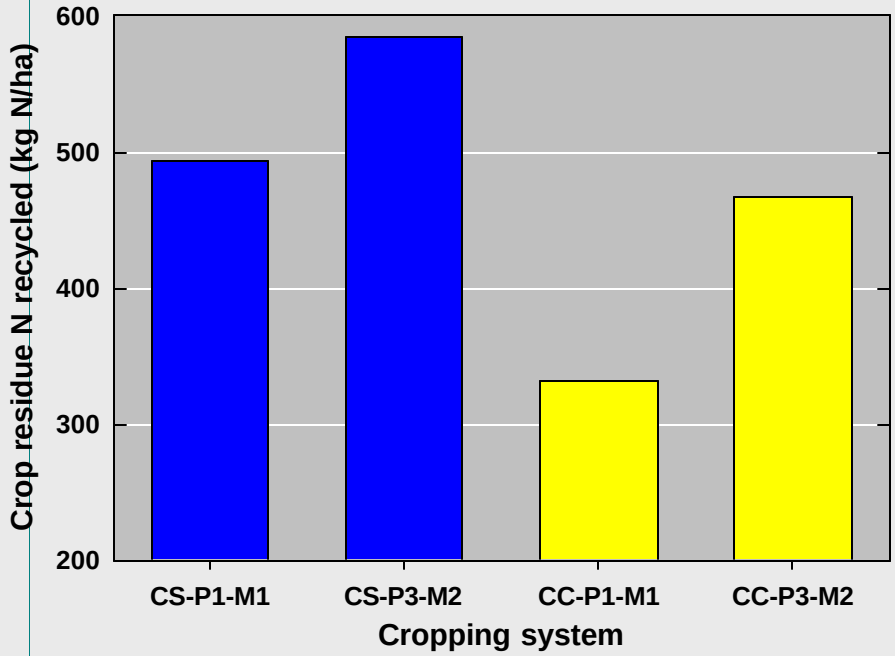

July 21, 2000
ROT CC
FERT 0
POP 44
ROT CC
FERT M1
POP 44
ROT CC
FERT M2
POP 44
ROT CC
FERT 0
POP 44
ROT CC
FERT M1
POP 44
ROT CC
FERT M2
POP 44

Cumulative Carbon and Nitrogen Input from Crop Residues, 1999-2002

Carbon (1000 kg/ha)



Nitrogen (kg/ha)



Total input of aboveground crop residues during 4 years (1999 to 2002). Belowground residues add another 15-20% of aboveground biomass inputs.

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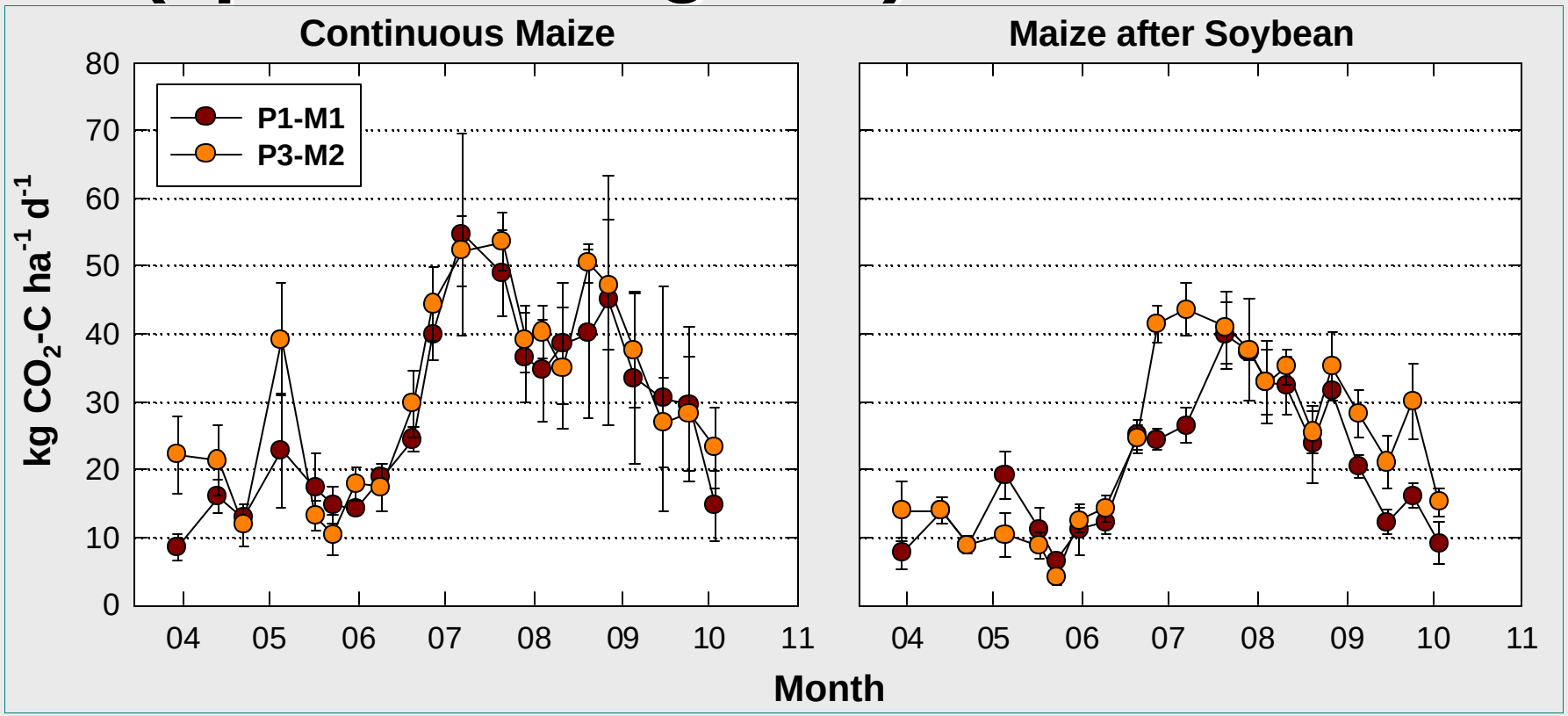
Soil CO_2 Emissions in 2003 (sprinkler irrigated)



Cumulative emission of CO_2-C during the growing season:

CC-P1-M1	**5200 kg C/ha**	**CS-P1-M1**	**3600 kg C/ha**
CC-P3-M2	**5600 kg C/ha**	**CS-P3-M2**	**4200 kg C/ha**

Vented closed chamber + photoaccoustic trace gas analyzer, fluxes measured a.m.

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EI Lincoln, NE: N rates

	Average	N rate 1999-2003 (lb N/acre)				
		1999	2000	2001	2002	2003
Continuous corn						
M1	**170**		181	179	161	161
M2	**268**		324	268	258	223
Corn after soybean						
M1	**116**	116	123	116	107	116
M2	**224**	201	266	214	193	223

M1: pre-plant & V6 M2: pre-plant, V6, V10, V12-VT

M1: no adjustment made yet for increasing SOM over time

CC-M2: 2002 includes fall application of 65 lb N/acre in 2001 (UAN, on residue)
2003 includes fall application of 45 lb N/acre in 2002 (UAN, on residue)

EI Lincoln, NE: N Use Efficiency

		Average 1999-2003			NUE 1999-2003				
Density	Fertilizer	N rate	Yield	NUE	1999	2000	2001	2002	2003
		lb N/acre	bu/acre	bu/lb N	bu/lb N				
Continuous corn									
P1	M1	170	217	**1.28**	-	1.18	1.25	1.11	1.59
P2/3	M2	268	247	**0.94**	-	0.71	0.94	0.94	1.18
Corn after soybean									
P1	M1	116	236	**2.04**	1.89	1.83	1.98	2.06	2.31
P2/3	M2	224	256	**1.16**	1.28	0.93	1.16	1.26	1.28

Highest-yielding M2 treatment: P2: 2000 and 2003 P3: 1999, 2001 and 2002

1999-2000	surface drip tape
2001-2002	sub-surface drip tape
2003	sprinkler irrigation

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EI Lincoln, NE: Nutrient Uptake and Removal

	Yield	Total uptake (lb per bu yield)					Net removal with grain (lb per bu yield)				
	bu/acre	N	P_2O_5	K_2O	Mg	S	N	P_2O_5	K_2O	Mg	S
CC-P1-M1	208	**0.98**	0.45	**1.52**	0.13	0.11	0.63	0.34	0.23	0.05	0.06
CC-P3-M2	239	**1.12**	0.42	**1.96**	0.12	0.11	0.68	0.33	0.22	0.05	0.05
CS-P1-M1	222	**1.02**	0.44	**1.53**	0.13	0.11	0.68	0.34	0.22	0.06	0.06
CS-P3-M2	243	**1.10**	0.43	**1.81**	0.13	0.11	0.67	0.34	0.22	0.06	0.05

Lincoln EI: Treatment averages of 1999-2002

EI Lincoln, NE: Row Spacing Study 2003

Row spacing inches	Target density plants/acre	Actual density plants/acre	Grain yield bu/acre
30	30000	29714	294.8
15	30000	29297	314.3
15	40000	37725	316.1
15	50000	42229	301.2

Row spacing x plant density study, Lincoln, NE, 2003

Hybrid: 31N28 (119 d)

Management: irrigated, very high nutrient rates (520 lb N, 210 P_2O_5, 210 K_2O)

Planting: 13-May

Emergence: 22-May

Maturity: 25-Sep

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Summary 1

- Average climatic corn yield potential about 300 bu/acre for most of the Corn Belt, with an amplitude of perhaps ±30 to 70 bu/acre, depending on location and year.

- Lincoln EI study: Max. yields of 245-285 bu/acre in each year. CS-P1-M1: 236 bu with 116 lb N applied.

- Yield increased with increasing plant density, provided nutrient supply was also increased. Highest yields: 35-40k.

- Total uptake of N and K per bushel yield increased at high yield levels. Net grain nutrient removal per unit yield was not affected by management or yield level.

Summary 2

- Large amounts of crop residue C and N are returned to the soil. Amounts and proportions of C and N in residue vary widely among the cropping systems evaluated. Impact on soil C and N dynamics is likely to be significant in terms of sequestering C and N.

- Very high NUE in M1 treatments, improving over time in M2.

- Yields of at least 80% of the yield potential are achievable and profitable under production conditions, without excessive input use.