Cover Crops
History and Current Practice

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Cover Crops

- crops whose main purpose is not the production of a harvestable product
- "cover crops" evolved from the concept of green manure
  - green manures are incorporated into the soil
- wisdom known to the ancients
  - Virgil (70 – 19 BCE) authored *Georgics*, a tome on all aspects of agriculture
    - alfalfa, clovers, lupine for increased wheat yields

Long History in Maryland

- depleted soils by time of American Revolution
  - tobacco monoculture, with clean tillage
  - severe erosion
  - switched to wheat and corn
- *Soil Exhaustion as a Factor in the Agricultural History of Virginia and Maryland, 1606 to1860* (Avery Craven, 1965, University of Illinois history professor)

Founding Fathers and Agricultural Innovators

- Jefferson and Washington (late 1790s)
- grasses and legumes in rotation with tobacco, wheat and corn
  - adequate feed source for cattle; manure!
- restore depleted land to reduce emigration and starvation
- 1860s before practices were widely adopted

UNIVERSITY OF MARYLAND
Agricultural Experiment Station

Effects of Winter Cover Crops On Growth, Quality and Nitrogen Nutrition of Maryland Tobacco

Results of cooperative investigations by the Maryland Agricultural Experiment Station and the Maryland Tobacco Improvement Foundation, Inc.

G. L. Steffens and O. E. Street

April, 1957
Bulletin A-86

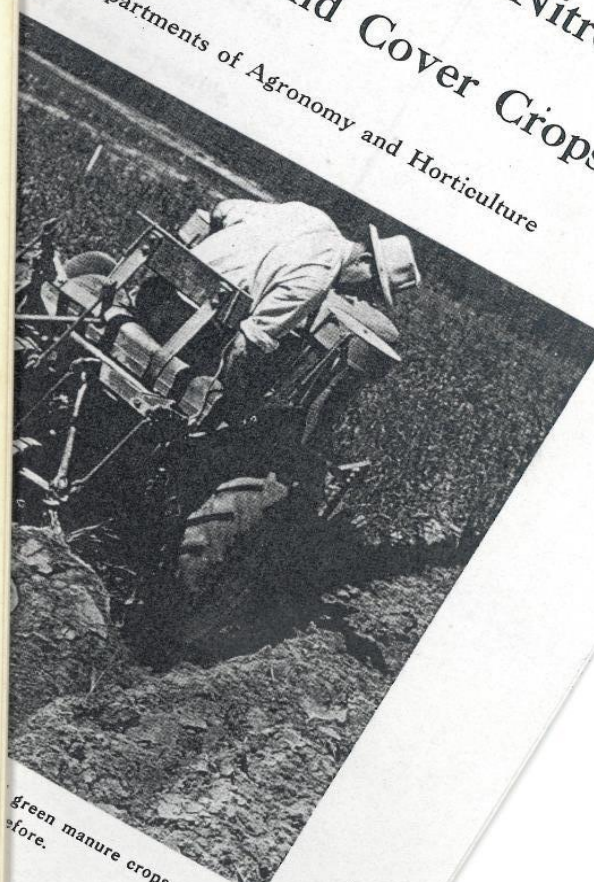
Circular No. 139

Morris

August, 1942

Accumulating Soil Nitrogen By Manure and Cover Crops

Departments of Agronomy and Horticulture



...green manure crops
...efore.

Roles of Cover Crops

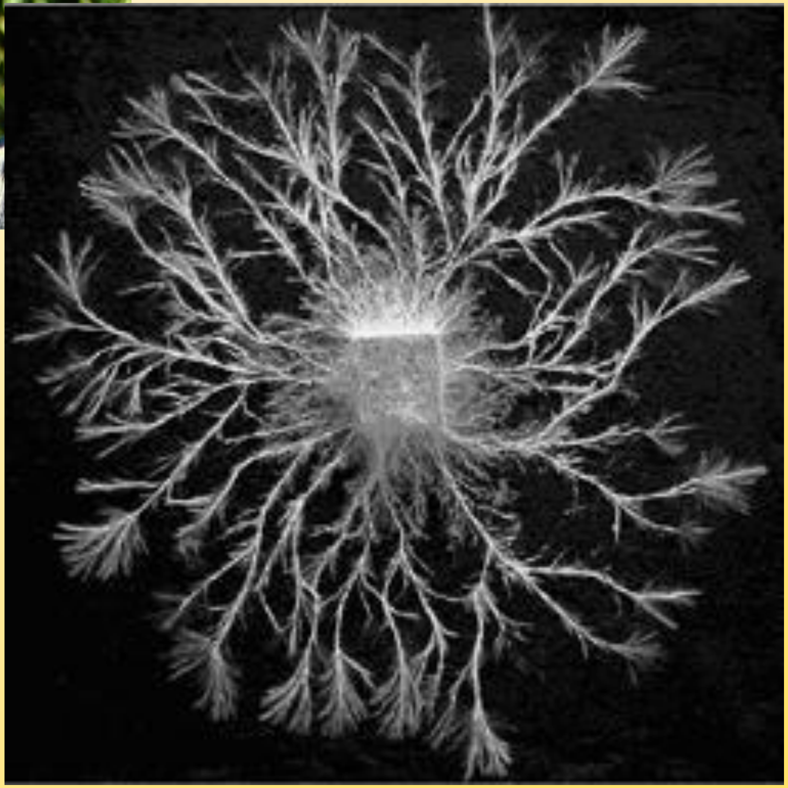
- erosion control
- source of organic matter
- N source (legumes)
- nitrate scavenger
- pest control, especially nematodes
- compaction reduction

Cover Crops for Erosion Control

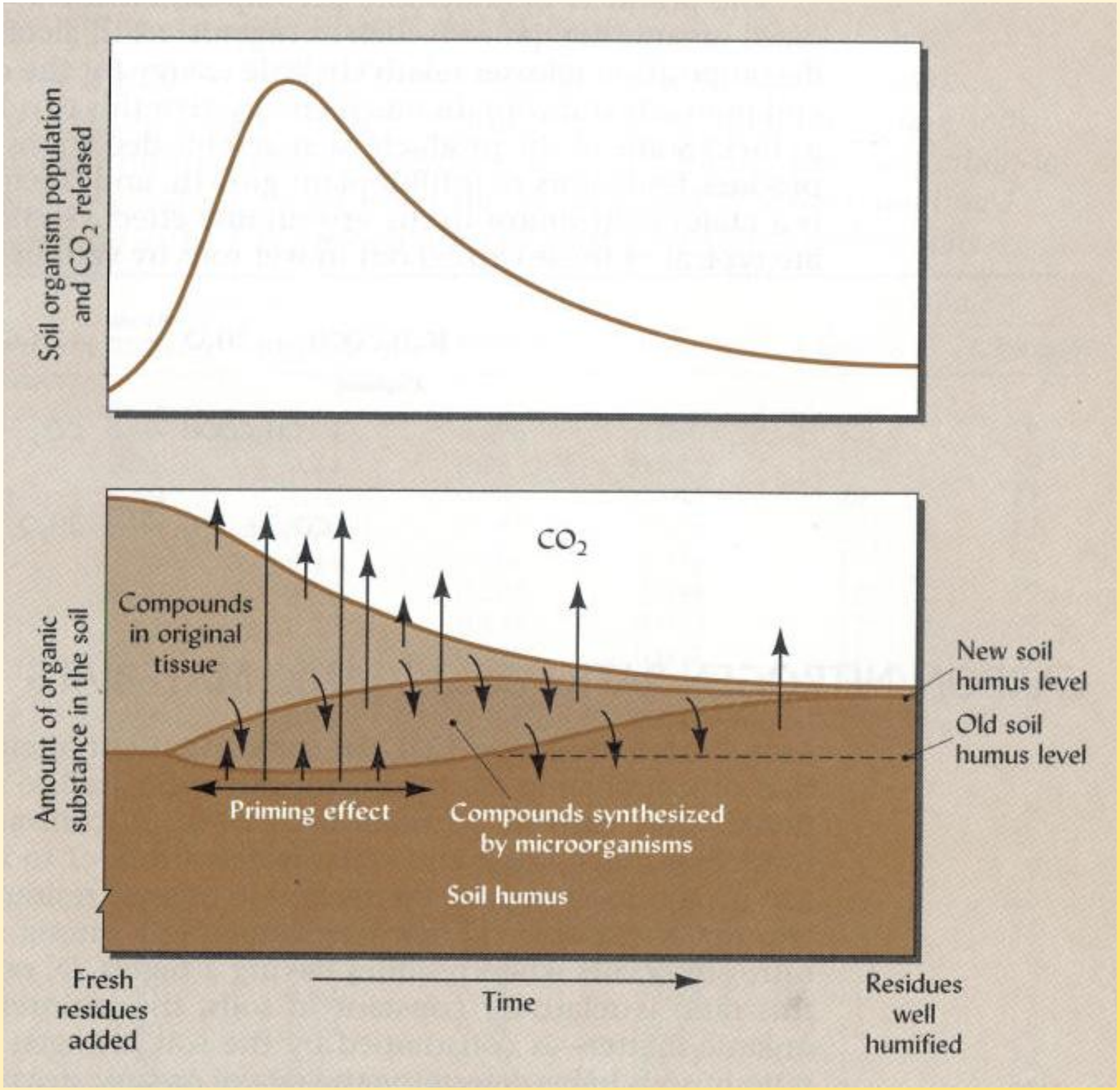
- soil surface is protected by above-ground biomass
- goal: good stand and rapid growth
- soil loss seldom measured
  - Zhu et al (MO, AJ 1989)
    - no cover –1.1 t/A
    - chick weed - .2 t/A
    - brome grass - .1t/A

Cover Crops for Organic Matter

- OM inputs from roots during growth, from shoots when CC is terminated
- cascading series of benefits from organic inputs
  - plant roots and fungi enmesh soil particles
  - stimulates biological activity
    - feeds the microbes
  - plant roots and microbes exude binding agents
    - plant and microbial mucilages
  - increase in large aggregates/improve soil structure
  - decrease in bulk density/increase in pore space
  - increase in infiltration rate and hydraulic conductivity
  - improve soil tilth or soil quality



plant roots and microbes, especially fungi, enmesh soil particles


Soil organism population and CO_2 released
CO_2
Compounds in original tissue
New soil humus level
Old soil humus level
Amount of organic substance in the soil
Priming effect
Compounds synthesized by microorganisms
Soil humus
Fresh residues added
Time
Residues well humified

Cover Crops for Nitrogen Acquisition

- legume/Rhizobia teams are the most efficient N fixers
- N fertilizer equivalence, NFE (N credit)
  - only a portion of the N fixed is available to next crop
- N delivery
  - given the tillage system and weed control, how much N can a grower actually count on

Hairy Vetch: Winter Legume of Choice in Mid-Atlantic

- maximum N contribution at flowering
- mechanical termination is most effective when vetch is flowering
- tradeoff between maximizing N production and optimal planting date of spring crop
  - early flowering cultivars (Auburn cultivars) flower 2 weeks earlier

Termination and N Credit

- wide ranges of N credits for winter annual legumes
- research at USDA/BARC indicated GDU can be used to determine optimal termination date (Teasdale et al., Agron J, 2004)
  - 926 $GDU_{base\ 40F}$ after planting to supply 120-140 pounds N/acre to next crop

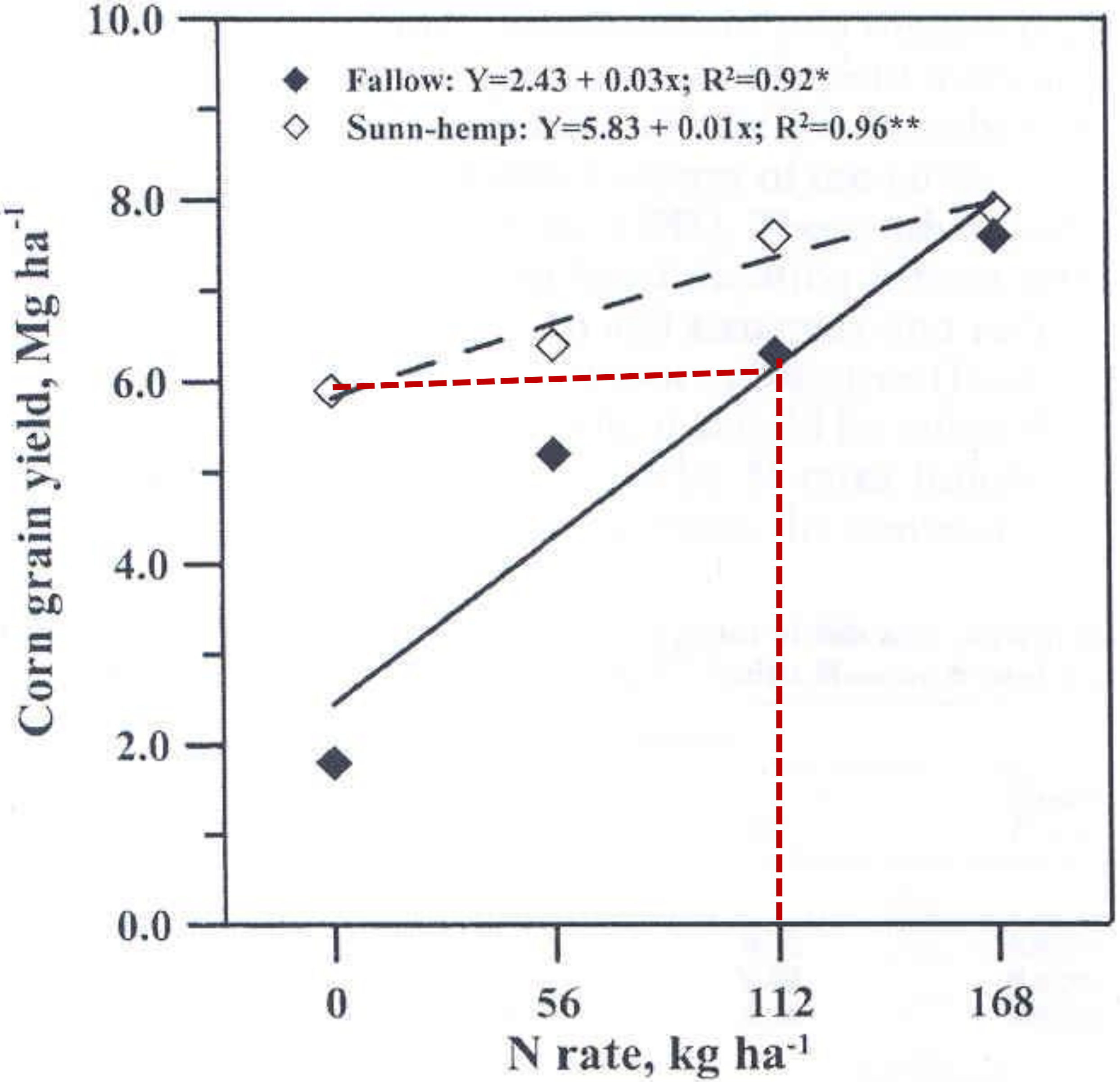
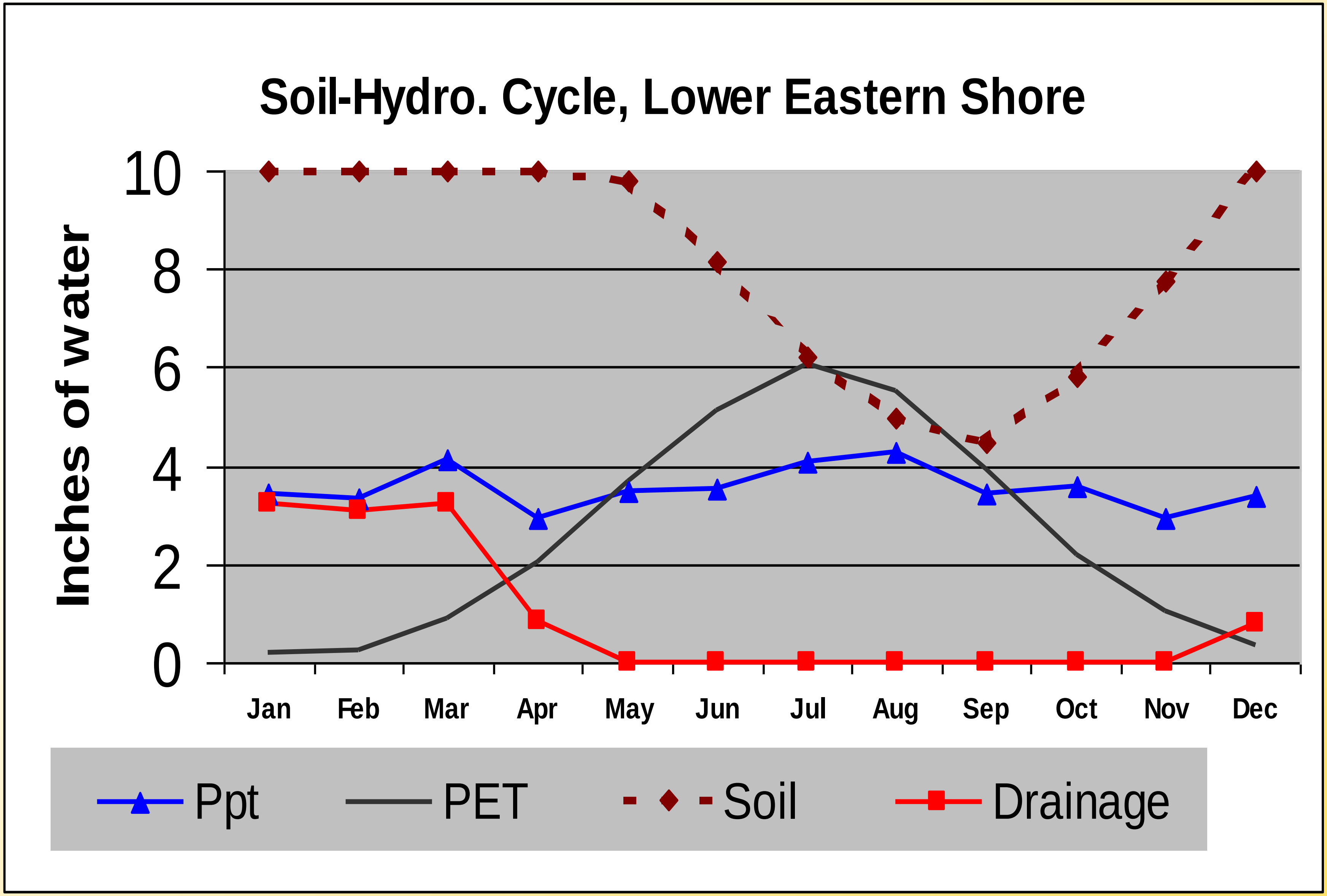


Fig. 1. Corn grain yields in 1991 following sunn-hemp and fallow plots measured across four N rates at the E.V. Smith Research and Extension Center in Shorter, AL.

Balcom et al.
Agron J. 97:28

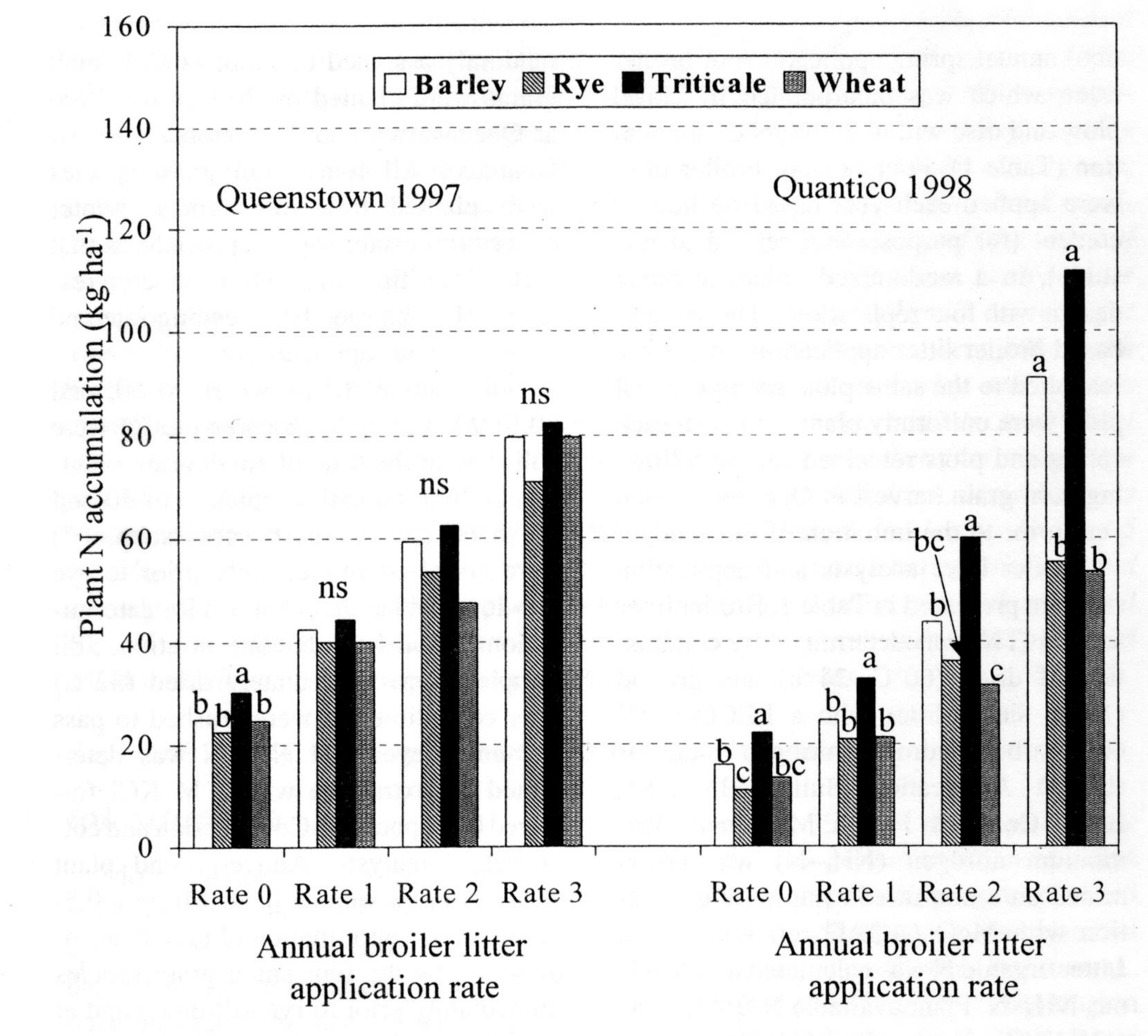
Cover Crops as Nitrate Scavengers

- non-legume crops, especially small grain crops
- nitrate uptake in fall prior to “leaching season”
- nitrate is incorporated in CC biomass and thus protected from leaching


Soil-Hydro. Cycle, Lower Eastern Shore
Inches of water
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ppt
PET
Soil
Drainage

Optimizing Scavenging

- choice of crop
  - non-legume
  - rye, wheat, barley?
- planting date
  - the earlier the planting date, the greater the uptake
- kill date
  - C/N or growth stage or GDU

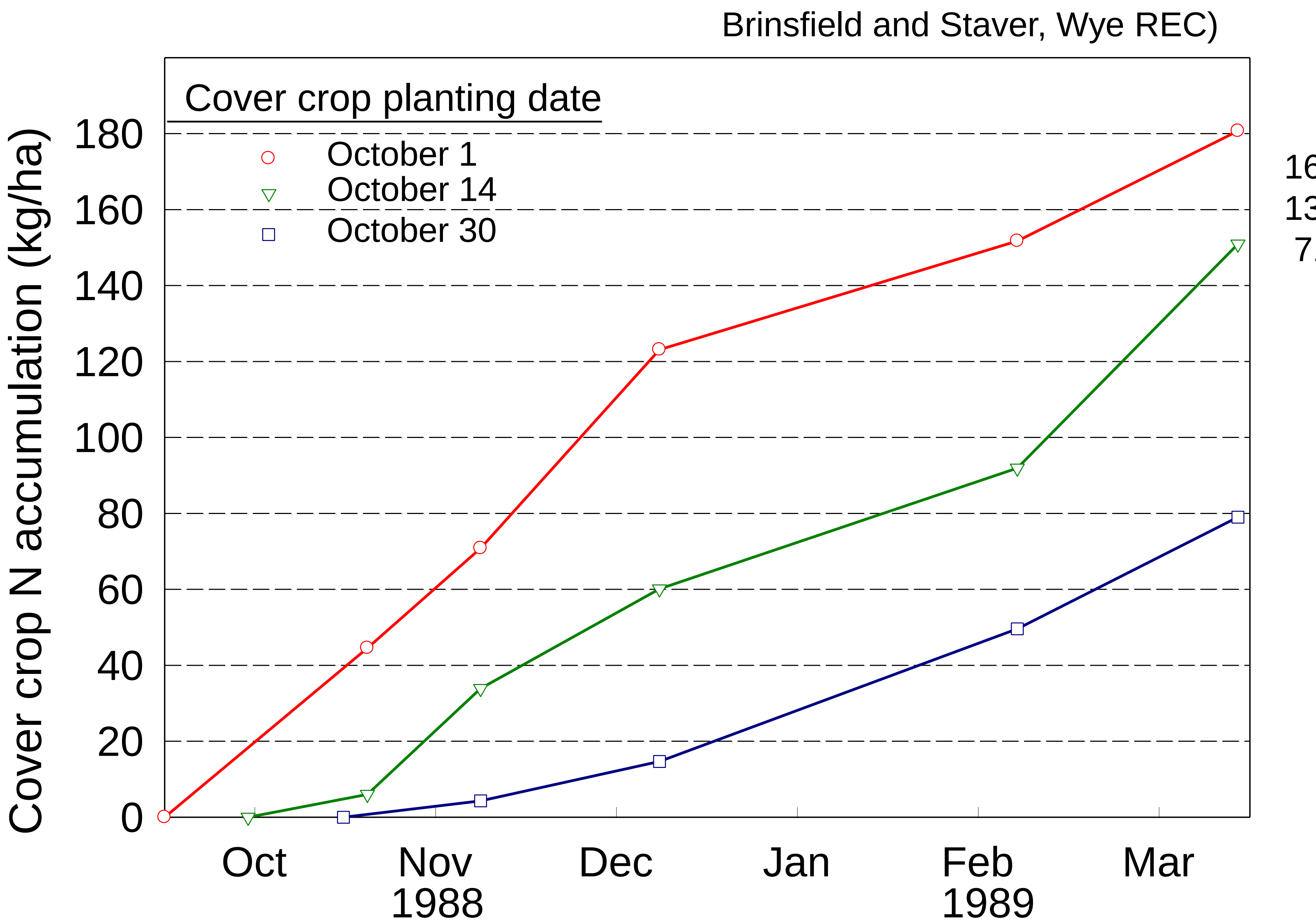


Coale et al. 2002

Species and Varietal Differences

(Costa, Bollero and Coale, 2000, Journal of Plant Nutrition)

- 25 wheat varieties compared to rye (var. Wheeler)
- little difference in early season N uptake (pounds per acre)
  - rye – 34
  - 1/3 of wheat varieties had higher uptake (36)
  - average wheat uptake - 31 pounds per acre
- At physiological maturity, 20 pound per acre N uptake difference between wheat varieties (60 vs. 80 pounds per acre)


Brinsfield and Staver, Wye REC)
Cover crop planting date
October 1
October 14
October 30
Cover crop N accumulation (kg/ha)
180
160
140
120
100
80
60
40
20
0
Oct
Nov
1988
Dec
Jan
Feb
1989
Mar
16
13
7

Dry Matter (DM), Nitrogen uptake and Carbon - Nitrogen Ratio (C/N) of Rye

	Piedmont			Coastal Plain		
	‘90			‘90		
Kill Date	DM t/A	N lbs/A	C/N	DM t/A	N lbs/A	C/N
early winter	.4	20	*15*	.2	13	11
late March	.6	28	20	.7	25	24
early April	.7	28	21	1.4	36	33
late April	1.6	43	32	1.8	30	57

Coastal Plain - Matapeake sil
Piedmont - Chester sil
Clark and Decker

N Uptake by Wheat (Rye) in Spring

(pounds N per acre, Beltsville, 2007-2008)

Kratochvil & Fisher, Agronomy Journal, 2011

	early estab.	**late estab.**
Broadcast	10 (21)	4 (11)
No-till drilled	25 (34)	19 (12)
Disked	18	12

early estab: 10-1
late estab: 10-20 to 11-1
dry summer, no rain until late Oct.

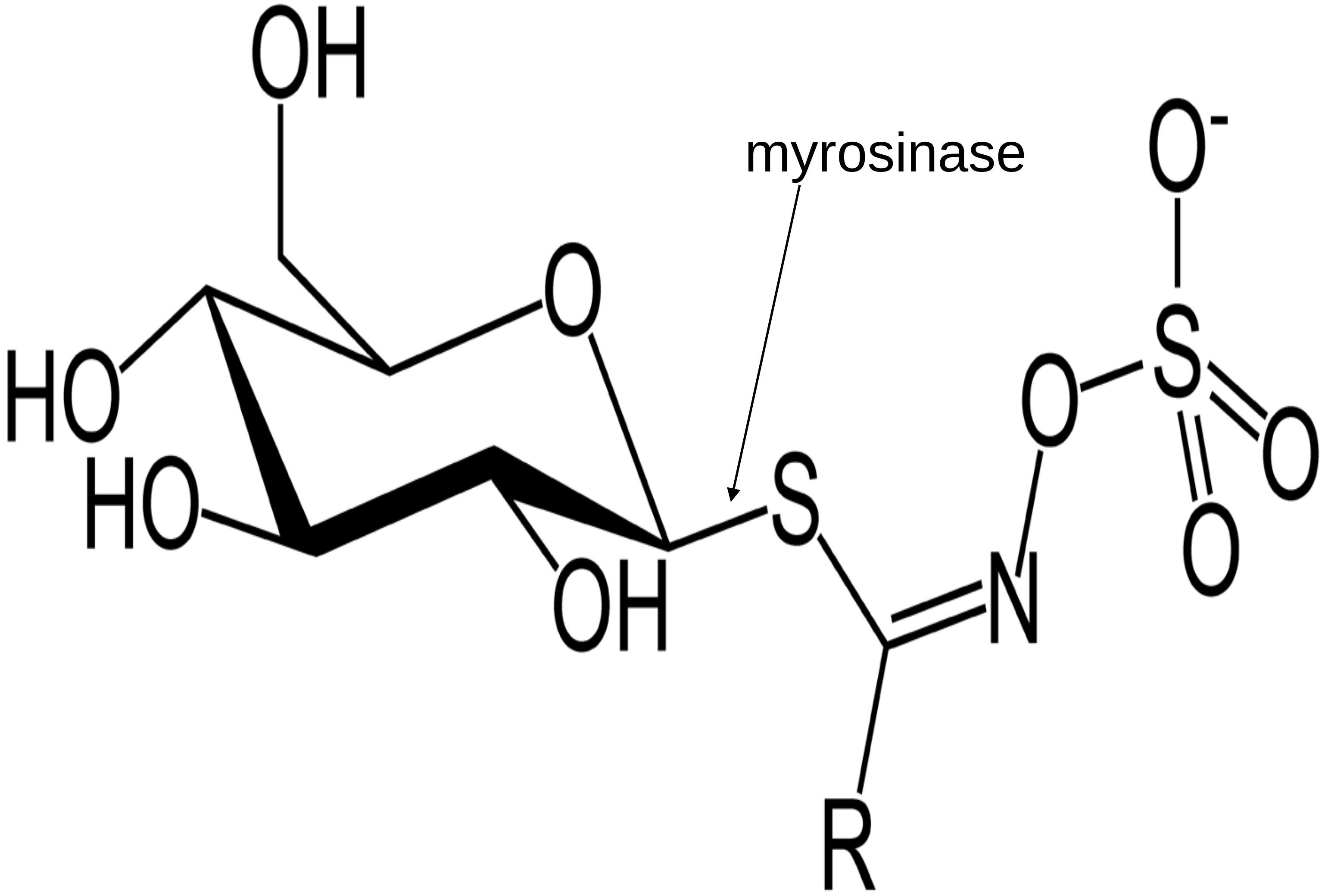
Corn Yield (bu/A) With and Without Preceding Rye Cover Crop

(Clark and Decker, CP, 1990)

Kill Date	N Rate (lbs/A)		
	0	80	160
early April			
check	60	72	117
rye	34	110*	120
late April			
check	74	118	154
rye	54	109	141

Cover Crops for Pest Control

- Brassicaceae family (crucifers)
  - canola, mustards, many other species
- "biofumigant" crops
- glycosinolates
  - secondary metabolites
  - hydrolyzes (reacts with water)
  - produces isothiocyanates and other toxic molecules
    - potential nematicide (root knot nematodes)
    - substitute for banned chemicals (methyl bromide)


OH
HO
HO
O
OH
myrosinase
S
N
R
O-
S
O
O
O
O

Examples of Breakdown Products

- variety of breakdown products
  - isothiocyanates (ITC)
  - thiocyanates
  - organic cyanides
- short-lived effects, differ in toxicity
- taste bitter
  - protection mechanism against herbivores

Effective Use of B. Family for Pest Control

- enzyme which activates breakdown (myrosinase) is partitioned within each cell
  - cell walls must be ruptured
  - mow with a flail mower
- many of the daughter compounds of glucosinolate breakdown are volatile
  - plow down immediately (no more than 2 hours)

Inconsistent Data on Effectiveness

- may or may not reduce nematode populations
  - when reductions were observed, effects lasted only 1 season
- may or may not increase yield of next crop
- not as effective as chemical treatments but inclusion in rotation should have a beneficial impact over time

Cover Crops for Alleviation of Compaction

- forage radish aka Daikon radish
- “biodrilling”
  - create low-resistance paths into subsoil that can be used by subsequent crop
- can be combined with small grain
- more effective in typical wet winters
- dual purpose
  - also effective nitrate scavengers

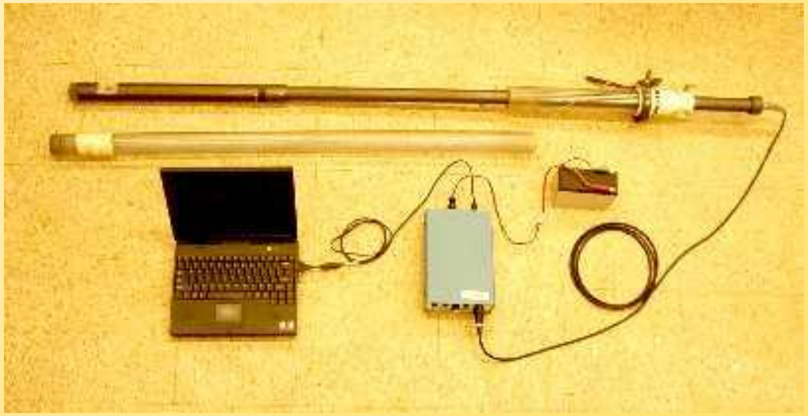
Forage Radish

- winterkill unless mild winter
- decomposition in late winter or early spring
- 12-18” long, 4-5” in diameter
- yield advantage in moisture-limiting seasons

Weil, 3-12

Minirhizotron Camera

- transparent tube buried in root zone
- special digital camera lowered into tube biweekly to observe root growth over time
- large channels made by forage radish through compacted layer were used by soybean crop
  - Weil and Williams



N Uptake Across Species

(pounds nitrogen/acre, WREC, 2003-2004)

	Fall		Spring
	shoots	roots	shoots
forage radish	39	30	
oilseed radish	33	18	
rape (canola)	44	12	105
rye	38		74

Weil et al.

Not Just in Fall and Winter

- summer cover crops
  - sorghum x sudangrass or sudangrass
    - for organic matter & soil quality
  - Sunn hemp
    - for N fixation

Which Cover Crop to Plant?

- What is the primary purpose?
  - scavenging unused nitrate?
  - alleviating soil compaction?
  - increasing OM & improving soil quality?
  - protecting soil from erosion?

- What season is the field available?

Including Cover Crops in Nutrient Management Plans

- scavenging N?
  - cover crops for water quality – crop code 51
    - lime rec is provided

- erosion control, nematode suppression, compaction alleviation or organic matter production in an N limited system?
  - modest N recommendations (20 - 50 pounds nitrogen/acre)

Questions or Comments?