Energy Resilience on the Farm

USDA NRCS Climate Hub Webinar Series
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Penn State Extension

RUTGERS COOPERATIVE EXTENSION

Webinar Preview:

Part 1: Farm Energy Resilience

Part 2: Energy Resilience in Crop Production

Part 3: Energy Resilience in Farmstead Operations

- Resilience: the ability to provide acceptable performance in the midst of abnormal events.

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- Farm Energy: the fuels and devices that use those fuels to carry out the work of the farm.

- Farm Energy Resilience: the ability of a farm to operate successfully in the face of abnormal energy issues

“Issues”?

- Loss of service reliability

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- Escalation of prices

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- Escalation of prices
- Changing energy needs

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- Changing market requirements

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Future Uncertainty

The dynamic energy environment for farms

- Climate – temp, rh, cloudcover, etc.
- Technology
- Market/Economy
- Regulations (rules)
- Knowledge Base

Past approaches to farm energy have often been static

- Steady State Conditions
- Steady State Energy Resources
- Steady State Technology
- Steady State Objectives

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Replication

Past Approaches have Assumed a Certain Design Life

- Sometimes Accurate
- Sometimes Not

Built 1863

Opportunities for a More Resilient Approach to Farm Energy

- Future projections of performance
- Improved energy efficiency
- Energy Risk identification and mitigation
- Design for “soft” failure
- Monetary and non-monetary performance taken into consideration

How do we make farm energy resilience a deliberate part of an agricultural enterprise?

- Identify energy risks
- Establish projections of energy availability, needs, costs, and related conditions
- Develop Strategies
- Carry out Cost/benefit Analysis

Energy Resilience in Crop Production

Dr. Zane R. Helsel, Emeritus Extension
Specialist, Rutgers Cooperative Extension

Considerations

- Assumptions:

  1)climate will warm, greater variability in weather, thus narrower window to accomplish field operations, droughty periods more prevalent

  2) traditional fuel supply and prices will be in flux

Energy Resiliency

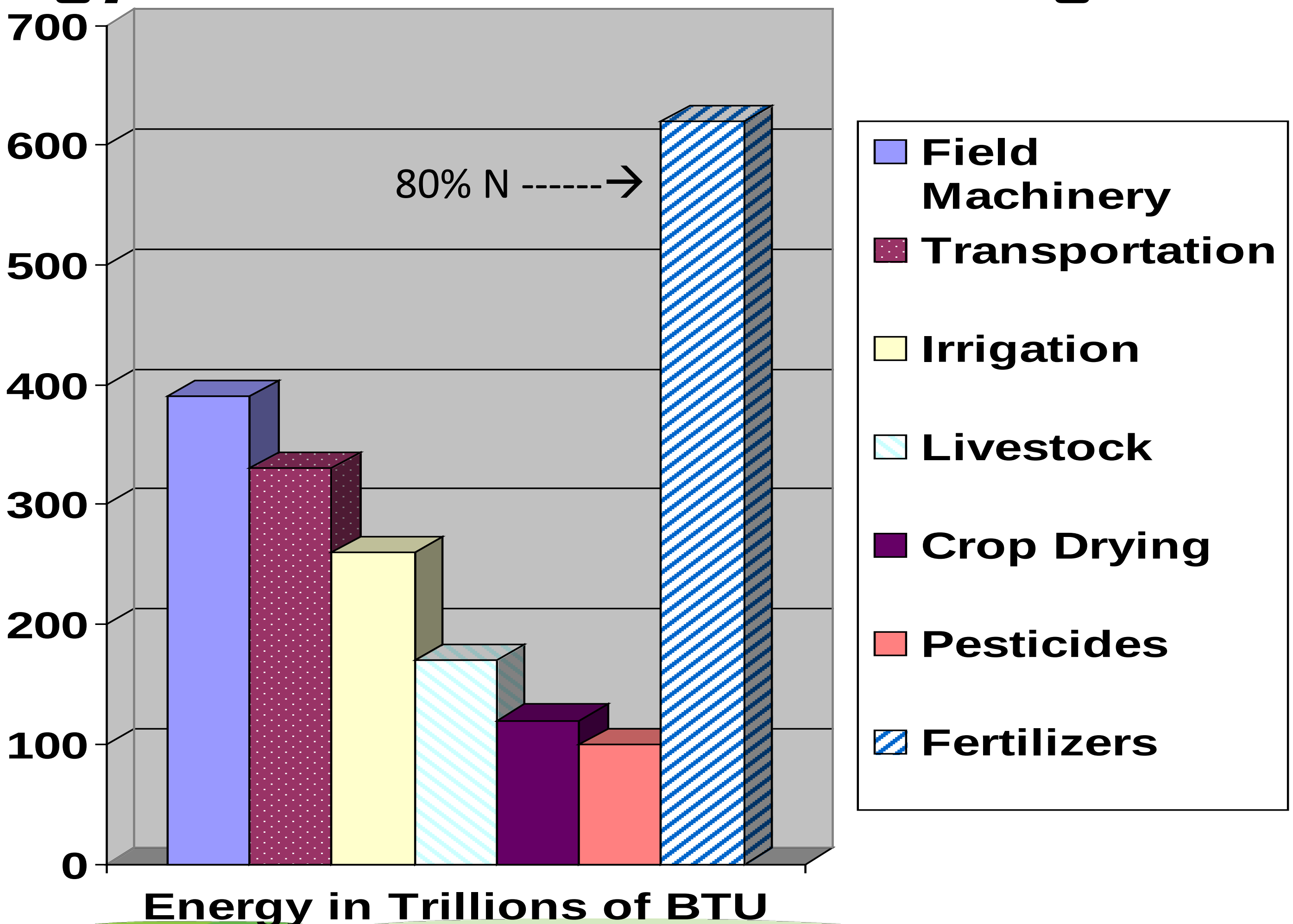
- Produce your own Biofuels/Renewables
- Conservation

a)reduce number of field operations and/or do more efficiently

b) recycle nutrients(manures/crop residues) and/or use more efficiently

c)collect/conserve/manage water

Energy Use in U.S. Production Agriculture



Source: USDA/FEA. 1976. Energy and U.S. Agriculture: 1974 Database (v. I), FEA/D-76/459. Washington, DC.: USGPO

Fuel Savings in Field Operations

Steps to Determine Fuel Use

1. Top off tank
2. Conduct field operation on a certain acreage
3. Refill tank and record gallons
4. Divide gallons of fuel by acreage (gals/acre)
5. Compare usage to the benchmarks for similar operations (next slide)

Table 1. DIESEL FUEL CONSUMPTION (GALLONS PER ACRE) FOR FIELD OPERATIONS

Operation	Michigan Farm Energy Audit *			Average from other States**
		Range		
	Average	High	Low	
Primary Tillage				
Moldboard Plow	1.81	3.50	0.90	1.87
Chisel Plow	1.36	3.50	0.80	1.09
Offset Disc	1.11	1.20	0.90	0.97
Subsoiler	1.54	2.30	1.10	1.56
Secondary Tillage				
Disc	0.93	3.30	0.30	0.65
Field Cultivator	0.78	1.80	0.30	0.68
Spring Tooth Harrow	0.73	1.80	0.20	0.48
Fertilizer/Chemical Application				
Pesticide Spraying	0.33	2.90	0.10	0.13
Chemical Incorporation	0.80	1.10	0.50	----
Spreading Fertilizer	0.30	0.50	0.10	0.19
Knife in Fertilizer	0.58	1.30	0.20	1.05
Planting				
Row Crop Planter	0.51	1.00	0.20	0.54
Grain Drill	0.56	2.31	0.10	0.33
Potato Planter	0.95	1.90	0.90	0.95
Broadcast Seeder	0.28	1.12	0.10	0.15
No-Till Planter	0.68	----	----	0.43
Cultivation				
Cultivator	0.39	1.90	0.10	0.42
Rotary Hoe	0.23	0.70	0.10	0.21
Forage Harvesting				
Mower/ Conditioner	0.72	1.80	0.30	0.66
Rake	0.46	1.26	0.20	0.24
Baler	0.65	2.90	0.10	0.69
Large Round Baler	0.80	---	---	---
Forage Harvester/Green Chop	1.57	2.00	0.20	1.87
Corn Silage Harvester	3.14	6.70	1.70	2.69
Crop Harvesting				
Small Grain or Bean Combine	1.23	1.80	0.70	1.01
Corn Combine	1.51	2.20	0.70	1.37
Corn Picker	1.84	3.00	1.20	1.10
Pull & Window Beans	0.52	1.10	0.30	0.34
Beet Harvester	1.37	1.90	0.90	1.91
Topping Beets	0.83	1.20	0.40	1.47
Potato Harvester	2.69	---	---	1.73
PTO Operated (gal/hr)				
Forage Blower	2.19	6.20	0.90	
Irrigation	3.41	4.40	1.10	
Grinding	3.84	6.90	2.20	

*Adapted from Helsel, Z. and T. Oguntunde. 1985.Fuel Requirements for Field Operations with Energy Saving Tips. In: Farm Energy Use: Standards, Worksheets, Conservation C. Myers(ed). Michigan State University, East Lansing, MI

**Iowa, Pennsylvania, Nebraska, Missouri, New York, Ontario, Oklahoma, North Dakota

Benchmark fuel usage by type of operation

NRCS Resources

nrcs141p2_023113.pdf

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_023113.pdf

NRCS Natural Resources Conservation Service

New Jersey

ENERGY CONSERVATION SERIES:

Agricultural Energy Consumption In the United States

In the United States, agricultural operations are highly dependent on machinery, chemicals, and other inputs which reduce labor costs and enable higher yields. Energy use is closely tied to the efficiency of these operations. A comprehensive analysis of the particular ways in which energy is used in agriculture, and an equally comprehensive analysis of the relative efficiencies of these various uses, is therefore warranted for the benefit of farmers and the consumers of their products.

Filling tractor fuel tank
PHOTO: NINA McKITTRICK

The U.S. food system accounted for 15.7 percent of total U.S. energy consumption in 2007, up from 14.4 percent in 2002 (10). On-farm production amounts to approximately 20% of the total system energy, while 40% of agricultural energy use goes into the manufacture of chemical fertilizers and pesticides (9). However, agriculture consumes more petroleum products than any other single industry in the food system (10).

field, while the second represents total equivalent amounts of energy consumed in the manufacture and application of fertilizers and pesticides used. This data reflects use levels found with conventional management techniques in 1976, as no newer information is available.

It is evident that the cultivation of different crops results in significantly different energy expenditures. Fruits and vegetables may require high levels of fungicide and insecticide use, often along with high levels of fertilizer use. Soybeans, oats and wheat, on the other hand, show a low level of fuel use since they require fewer field operations and less fertilizer. All these crops can vary considerably in energy use based on their management and place in the overall cropping system.

Energy use in greenhouse operations is quite different from field crops. In New Jersey, winter heating may use 1 gallon equivalent of fuel oil per square foot, plus or minus 0.5 gallons depending on location and type of structure, among other factors.

Nursery production in the state is a significant enterprise, however, energy use data has not been calculated. Such energy use could be high in farm operations where there is high production intensity.

Energy Use in Food Production

In 1996, United States production of animal proteins for food use consumed approximately 76,367 kilocalories (kcal) per kilogram of protein produced (2). Of all types of US protein products, the production of chicken is the most

Table 1- Inputs to Field Operations
Source: Federal Energy Administration (8)

Crop	US Gallons/ Acre Fuel Inputs	US Gallons/ Acre Chemical Inputs

NRCS Resources

Tillage System Equipment Use

6
- **Plow**
- Disc
- Disc
- Drag
- Plant
- Spray

Total, Gal/A = 5.1

4
- **Chisel plow**
- Field Cultivate with rolling baskets & tines
- Plant
- Spray

3.4

1
- **No-till**
  Plant
  Fertilize
  Spray

0.75

Match Tractor and Implement—use small (older) tractors for light jobs

Photo credit: Rachel Brickner http://commons.wikimedia.org/wiki/File:NAA_pulling_hay_rake.jpg#filehistory

Match Tractor and Implement—use large tractors for combination tillage tools

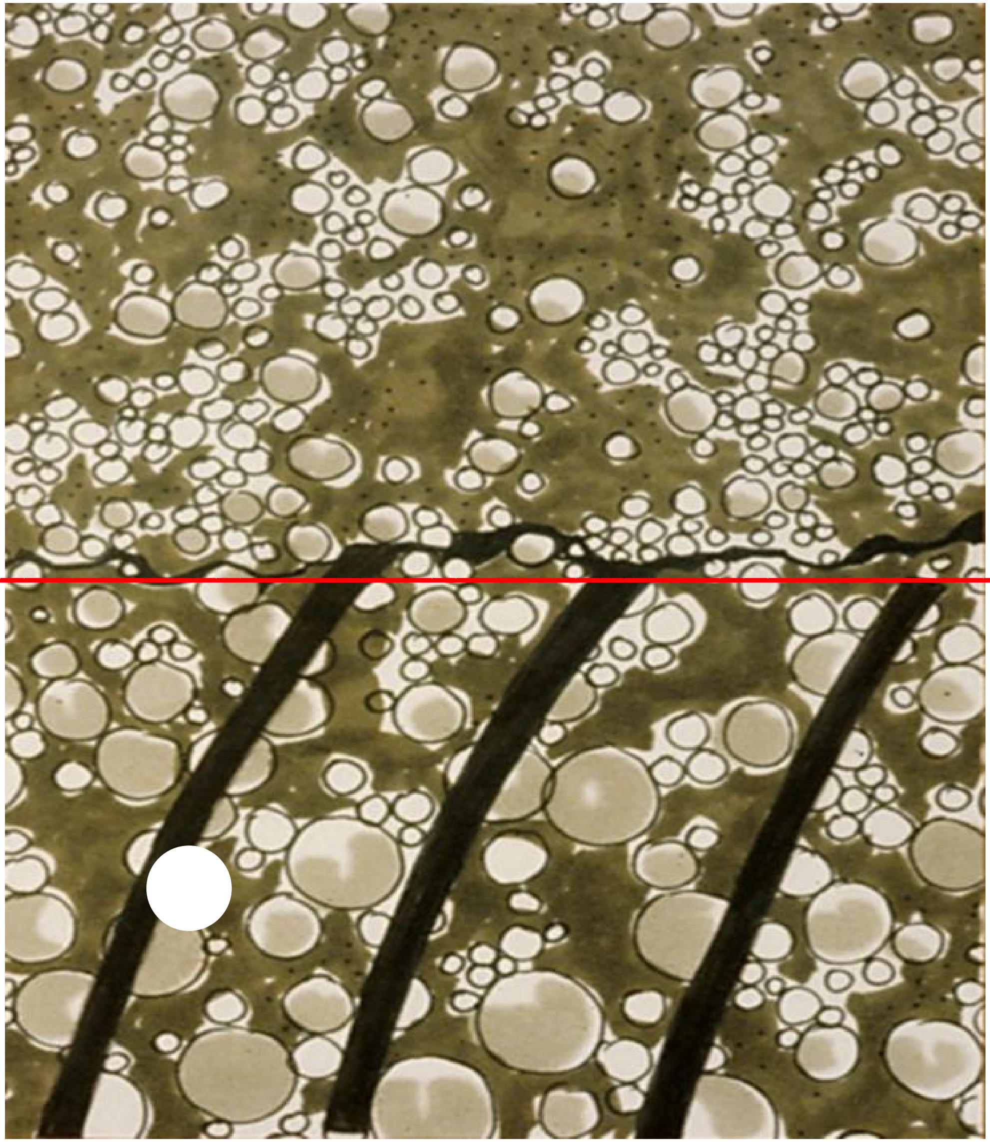
Proper Tillage Depth

Source: http://fyi.uwex.edu/discoveryfarms/files/2010/09/03.JPG

Tillage Depth

Secondary tillage (1/2 depth of primary or previous)

Primary tillage



Goal is to provide firm seedbed, not compacted soilbed!!!

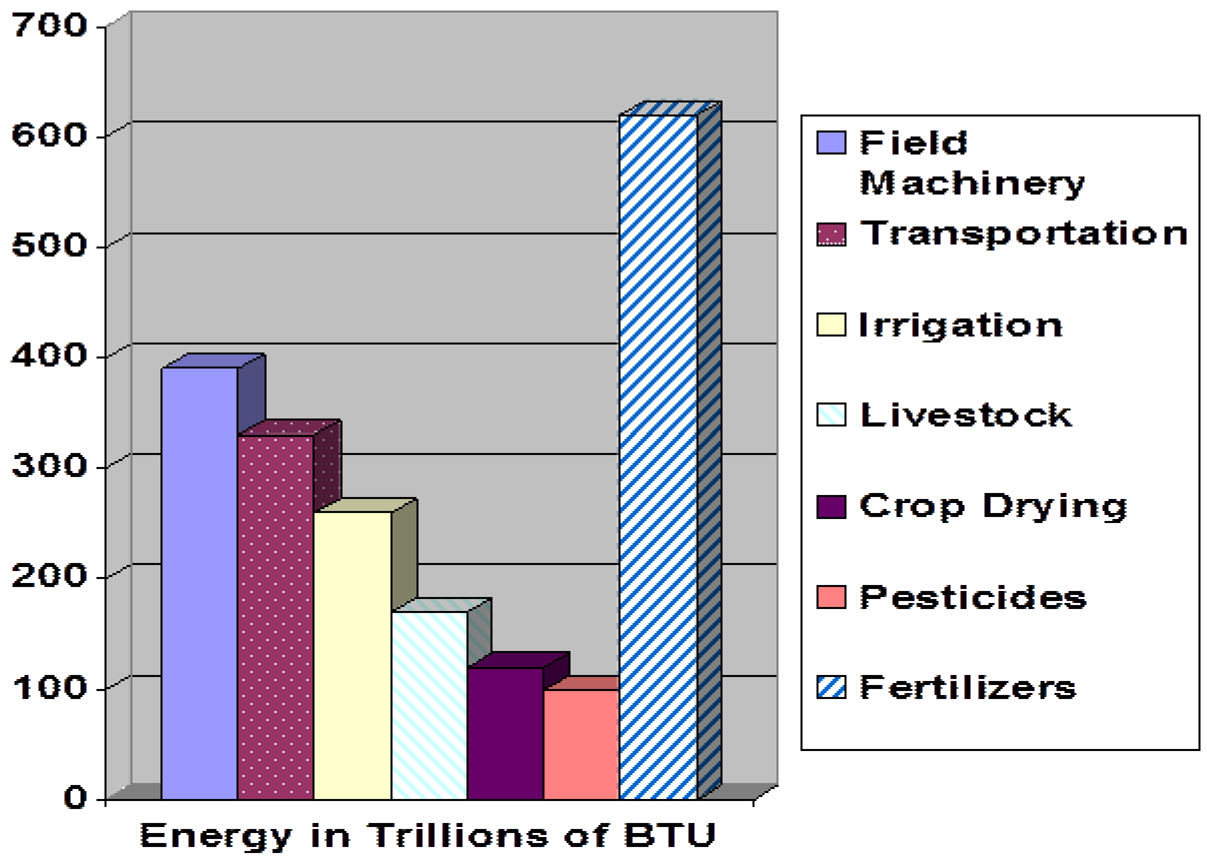
Other Field/Equipment Conservation Tips

- Avoid "Recreational" Tillage
- Proper Wheel Slippage/Ballast
- Reduce length and number of turns
- Gear Up-Throttle Down (CVT)
- Match Tractor and Equipment (small tractor for small equipment, Pony engines, etc)
- Combine equipment for 1 pass operation

Conserving Energy in Nutrient Use and Pest Control

Photo credit: http://www.extension.org/sites/default/files/w/4/4a/Spreading_manure.jpg

Energy Use in U.S. Production Agriculture



Source: USDA/FEA. 1976. Energy and U.S. Agriculture: 1974 Database (v. I), FEA/D-76/459. Washington, DC.: USGPO

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FS719

Fact sheet

Soil Fertility Test Interpretation

Phosphorus, Potassium, Magnesium, and Calcium

Joseph R. Heckman, Ph.D., Extension Specialist in Soil Fertility

Introduction

A soil fertility test evaluates the nutrient-supplying power of a soil. The results of the test are used to predict if, or how much fertilizer is required for optimum plant growth.

The conceptualized relationship between soil nutrient level and plant response is shown in Figure 1. Rutgers Cooperative Extension classifies relative fertility levels into three main categories: *Below optimum*, *optimum* and *above optimum*. *Below optimum* is divided into subcategories: *very low*, *low*, and *medium*.

These soil fertility categories gauge the probability of a plant showing a beneficial response to the addition of a given nutrient (assuming that other factors such as temperature, moisture, disease, etc. are not limiting growth).

The soil test categories as described in Table 1 are the basis for how much phosphorus (P) and potassium (K) to apply to reach optimum growth levels. For limestone recommendations, these categories indicate the concentrations of calcium (Ca) and magnesium (Mg) most suitable for use as a liming material.

Recommendations Based on Soil Test Categories

Soil test categories along with crop nutrient requirements are the basis for nutrient recommendations. Rutgers Cooperative Extension publishes production recommendation guides for vegetable, tree fruit, field crops, nursery crops and turf. These recommendation guides provide tables that indicate for various soil test categories how much phosphorus and potassium to apply to produce each crop.

For example, when the soil test category for K is *below optimum—low* the recommendation guide will indicate how much K to apply. The amount of K recommended however, varies depending on the crop. Various crops accumulate different amounts of nutrient. Generally, crops that produce large yields of harvestable material will remove large amounts of nutrients from the soil and will have a higher nutrient recommendation.

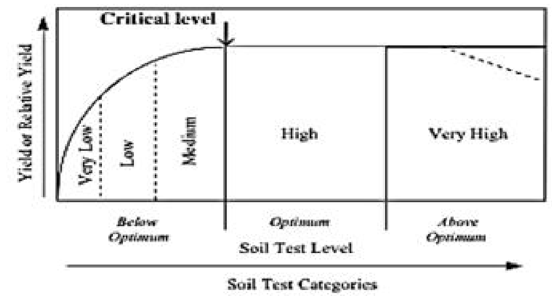


Figure 1. This conceptual soil test response curve is divided into categories that correspond with *below optimum*, *optimum* and *above optimum* soil test values. The critical level is the soil test level, below which a crop response to a nutrient application may be expected, and above which no crop response is expected. At very high soil test levels crop yield may decrease.

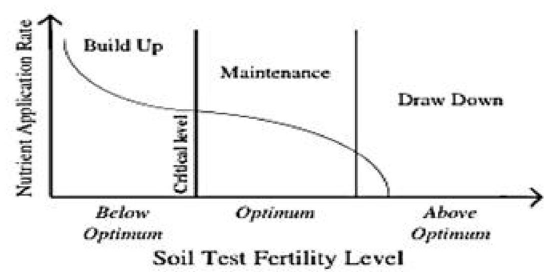
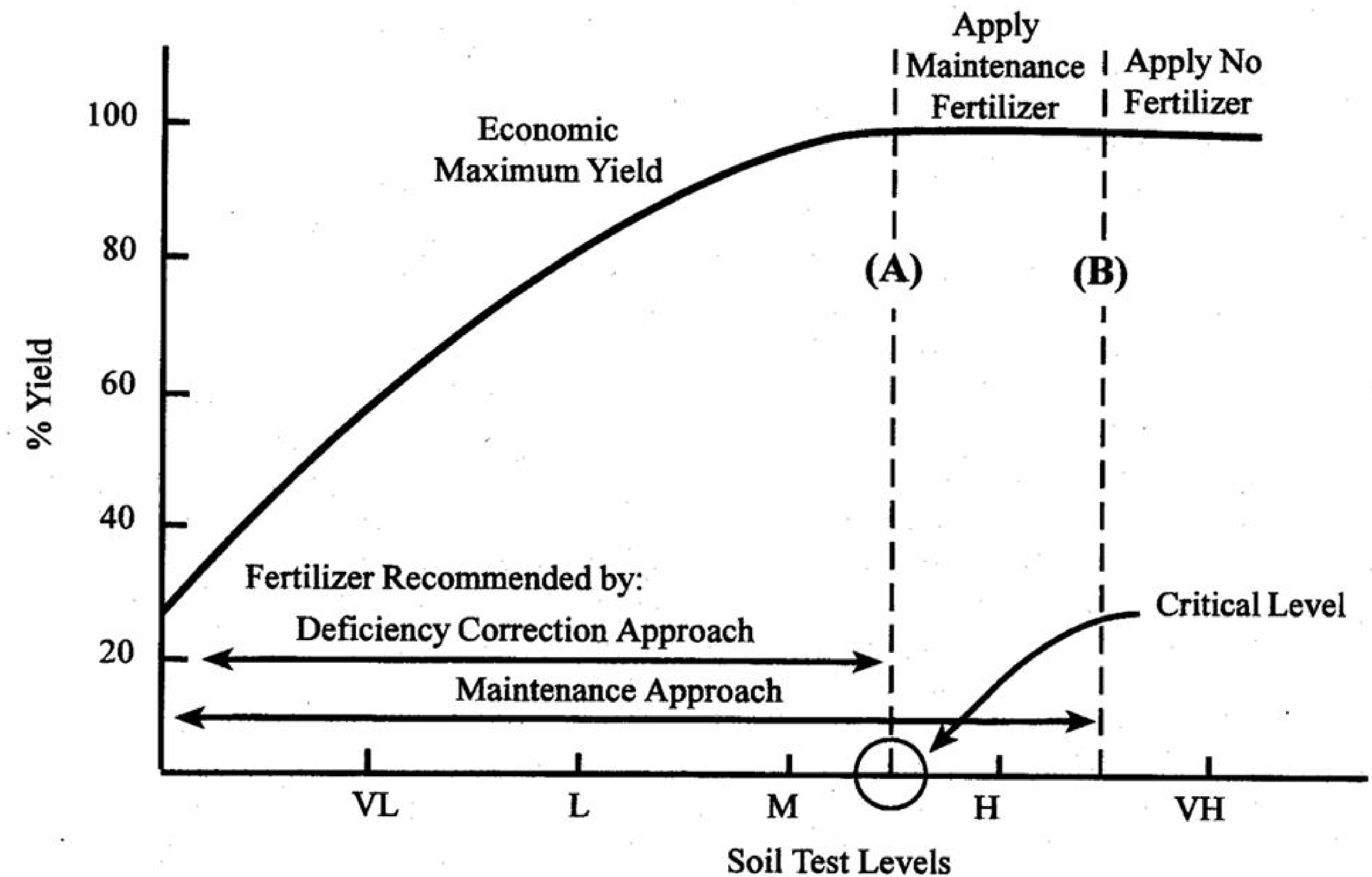


Figure 2. Nutrient application rates vary in relation to soil test category.

Crop Yield Response to Soil Fertility Levels



Source: http://passel.unl.edu/UserFiles/File/Crp.%20Prod.%20Nat.%20Res.%20Mngmt/Soils%20Lesson%2010/Fig-10.1.gif

Know Crop Needs

Crop (units)	N	P_2O_5	K_2O
	Per Unit of Yield		
Corn (bu)	1	0.4	0.3
Corn silage (T)[1]	7	5.0	11.0
Grain sorghum (bu)	0.75	0.6	0.8
Forage sorghum (T)[1]	7	3.0	10.0
Sorghum/sudangrass[1]	7	7.0	7.0
Alfalfa (T)[2,3]		15.0	50.0
Red Clover (T)[2,3]		15.0	40.0
Trefoil (T)[2,3]		15.0	40.0
Cool-season grass (T)[2,3]	50	15.0	50.0
Bluegrass (T)[2,3]		10.0	30.0
Wheat/rye (bu)[4]	1	1.0	1.8
Oats (bu)[4]	0.8	0.9	1.5
Barley (bu)[4]	0.8	0.6	1.5
Soybeans (bu)		1.0	1.4
Small grain silage (T)[1]	17	7.0	26.0

1. 65% moisture 2. For legume-grass mixtures, use the predominate species in the mixture 3. 10% moisture. 4. Includes straw

Source: Tables 1.2-5 & 1.2-8
2013-2014 PSU Agronomy Guide

Calibrate Equipment

Source: http://ncagr.gov


Banding Fertilizer
1/3 less fertilizer
needed
A B C GROFF, INC.

PSNT- Pre-sidedress N Test

Important where other sources of N are likely present in soil already, ie legume crops, manure, etc

Use Legumes for N & Tilth

Source: http://www.extension.org/sites/default/files/w/5/50/Sweet_clover_cover_crop.jpg

Residual Nitrogen Contribution from Legumes

Previous crop[1]	Percent stand	Highly-productivity fields	Moderate-productivity fields	Low-productivity fields
First year after alfalfa	Nitrogen credit (lb./acre)			
	>50	120	110	80
	25-49	80	70	60
	<25	40	40	40
First year after clover or trefoil				
	>50	90	80	60
	25-49	60	60	50
	<25	40	40	40
First year after soybeans harvested for grain	1 lb. N/bu soybean produced previous year			

(1) When a previous legume crop is checked on the Penn State soil test sheet, the residual nitrogen for the year following the legume is calculated and given on the report. This credit should be deducted from the N recommendation on the soil test. (2) See Table 1.1-1 in the basic soil test section for information on soil production groups. Adapted from 2013-2014 Penn State Agronomy Guide.

pH Management-Lime

http://www.extension.org/sites/default/files/w/3/3b/Limed_field.JPG

Using Manures

- Test for nutrient availability
- Incorporate into soil
- Apply close to crop growth needs
- Calibrate equipment

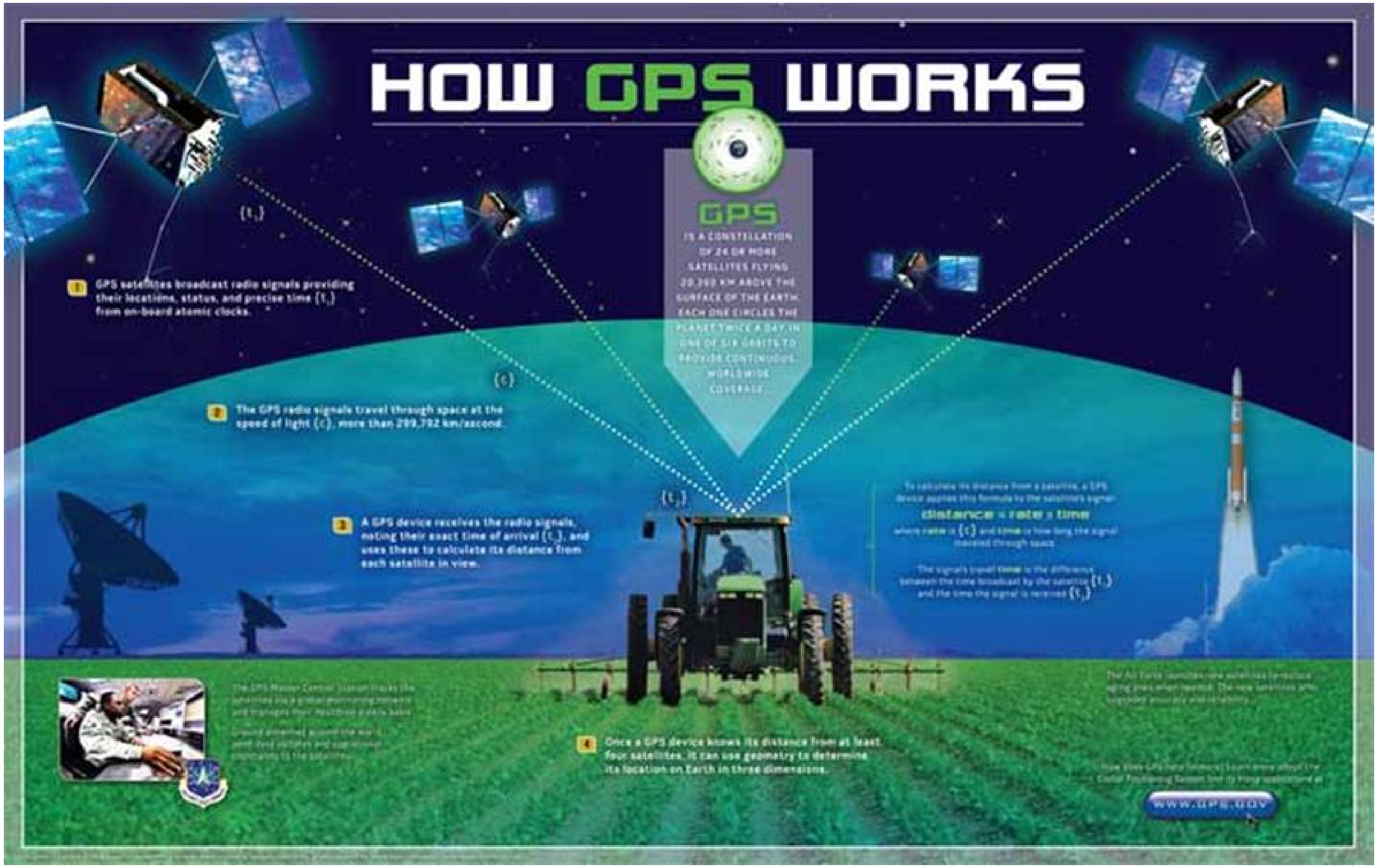
Source: http://www.uri.edu/ce/healthylandscapes/livestock/photos/BMPs/liqmaninj.jpg

Mechanical vs. Chemical Weed Control

Energy use for producing and applying glyphosate to corn and soybeans is about equal to energy use in rotary hoeing and two row cultivations. In climate-limited situations, herbicides will be faster.

Photo: http://www.organicriskmanagement.umn.edu/weed_management.pdf

Precision Ag/Guidance Systems (GPS)



Water!!!

- The # 1 factor effecting crop yield is availability of adequate water at the times needed by the crop.
- Climate Variability will likely effect amount and timing of Rainfall

Energy Efficiency in Irrigation

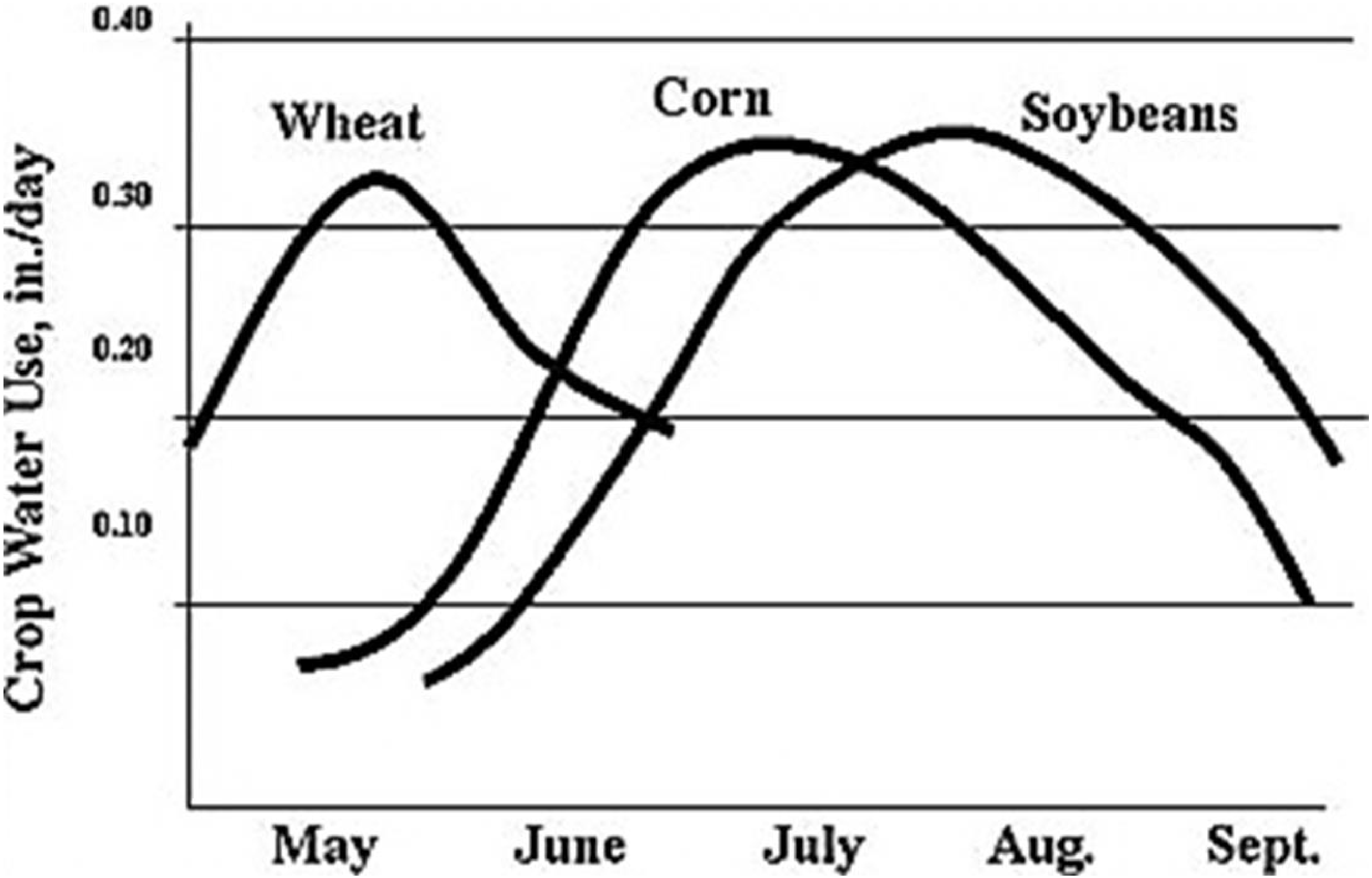
Photo: http://www.clemson.edu/irrig/images/SHTrav8.jpg

Opportunities to Reduce Energy/Save Water

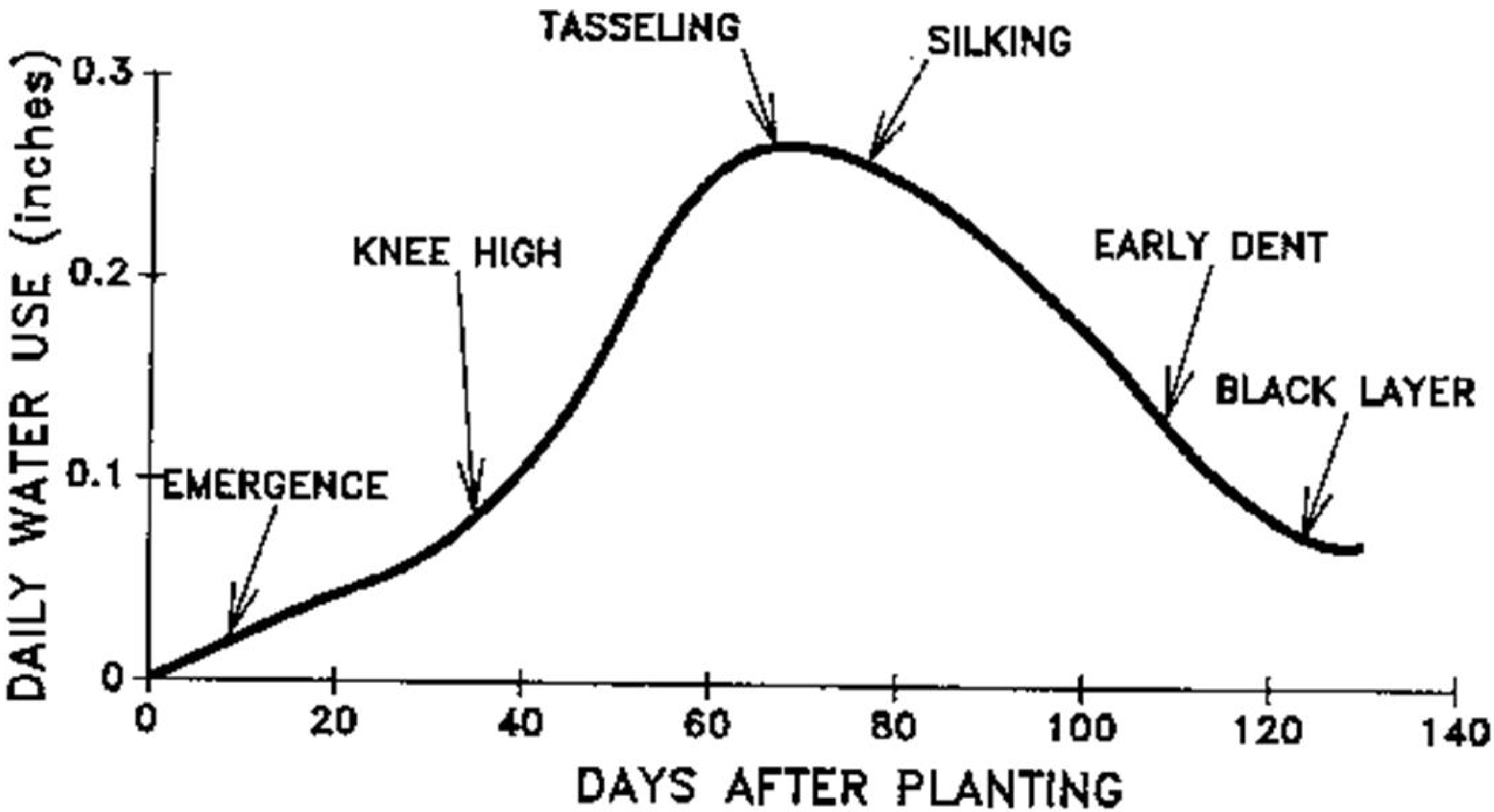
- Use least amount of water necessary
- Apply water efficiently
- Micro-irrigation methods (trickle, etc)
- Ponds (if you build them, they will provide!)
- Recycle Water("grey water"/runoff capture, ebb & flow,)
- Water retention (limit runoff, ie cover crops, no-till, etc)

Crop Needs

- Each crop requires different amounts at different times
- Crop growth stage (canopy, rooting depth)
- Weather conditions (evapotranspiration caused by temperature, relative humidity, wind, sun, day length)



Source: http://www.ext.colostate.edu/pubs/crops/04720.html



http://www.bae.ncsu.edu/programs/extension/evans/ag452-1.html

Average Root Depth of Corn and Soybeans at Various Growth Stages			
Corn Stage	Effective root depth* (feet)	Soybean Stage	Effective root depth (feet)
V10-12	2.0	V6	1
V16-VT	2.5	R1	1.5
R1	3.0	R3	2.0
R2	3.5	R6	2.0+
R3-5	4.0		

*Rooting depth maybe less due to compaction or limiting soil profile restrictions.

Source: National Corn Handbook

Soil Water Management

- Available water holding capacity
- Infiltration rate
- Depth restrictions

Available Water Holding Capacity

Soil		in./ft.
Sandy clay loam		2.0
Silty clay loam		1.8
Clay loam		1.8
Loam Very fine sandy loam Silt loam	Low OM	2.0
Loam Very fine sandy loam Silt loam	high OM	2.5
Fine sandy loam		1.8
Sandy loam		1.4
Loamy sand		1.1
Fine sands		1.0
Silty clay, clay		1.6

Adapted from the National Corn Handbo

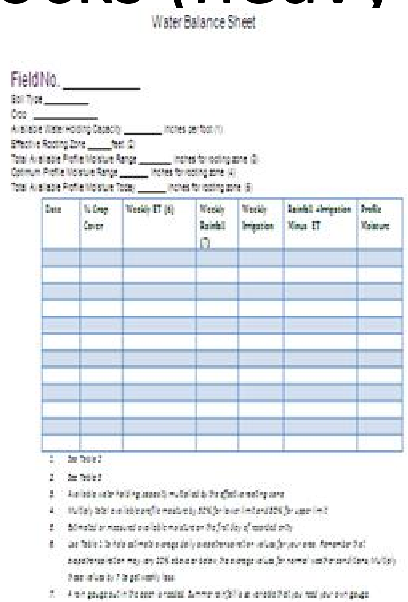
Suggested Maximum Water Intake for Various Soil Types	
Soil Types	Intake rate*
	in./hr.
Sands	2.0
Loamy sands	1.8
Sand loams	1.5
Loams	1.0
Slit and clay loams	0.5
Clays	0.2

* *Assumes a full crop cover. For bare soil reduce the rate by one-half*

Source: Michigan State University CES Ag Fact 137

Measuring Available Soil H_2O

- Feel method
- “Checkbook”
- Tensiometers (light soils)
- Moisture blocks (heavy soil)


Water Balance Sheet

Field No. __________
Soil Type ________
Crop __________
Available Water Holding Capacity ________ inches per foot (1)
Effective Rooting Zone _____ feet (2)
Total Available Profile Moisture Range _______ inches for rooting zone (3)
Optimum Profile Moisture Range ______ inches for rooting zone (4)
Total Available Profile Moisture Today ______ inches for rooting zone (5)

Date	% Crop Cover	Weekly ET (6)	Weekly Rainfall (7)	Weekly Irrigation	Rainfall +Irrigation Minus ET	Profile Moisture


www.aces.nmsu.edu

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Pumps and Plumbing

- Energy efficient power units
- Choice of pumps
- Reduce resistance/head
- Monitor efficiency
- Maintenance of system components

Photo: C. McKittrick, NJAES, Rutgers Univ

Plumbing

- Use pressure gauges
- Appropriate valves
- Check for leaks/restrictions
- Limit reducers, elbows
- Monitor coverage
- Provide uniform delivery
- Maintain system components

Produce Your own Biofuel/Renewable Energy

- Power Unit Fuel(soy/canola)
- Heat(combustion-Switchgrass, Bad Hay,etc)
- Methane Digestors
- Electricity(microdams/hydro)
- Solar & Wind,etc

Microhydropower Systems

Microhydropower Systems ×

Secure | https://energy.gov/energysaver/microhydropower-systems

Apps | Suggested Sites (2) | Dell Start Page | Suggested Sites | Free Hotmail | Suggested Sites (1) | Imported From IE | New Tab

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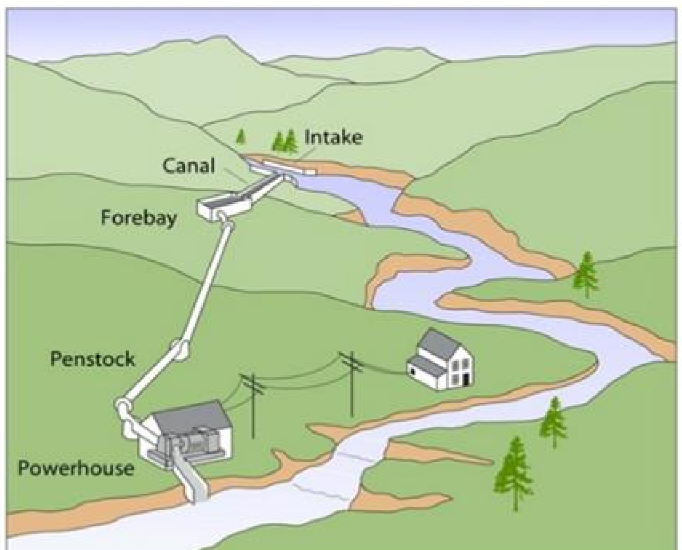

In this microhydropower system, water is diverted into the penstock. Some generators can be placed directly into the stream.

Microhydropower can be one of the most simple and consistent forms or renewable energy on your property.

If you have water flowing through your property, you might consider building a small

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Solar Panel Design Ideas for Your Home

Tax Tips for Energy Savers: Get Money Back for Greening Your Home

Energy Efficiency Tax Credits, Rebates and Financing: What Options Are Available for You?

REBATES & TAX CREDITS

A federal tax credit is available for **solar energy systems.** The credit is for 30% through 2019, then decreases to 26% for tax year 2020, then to 22% for tax year 2021. It expires December 31, 2021. Learn more and find state and local incentives.

The federal tax credit for **small wind energy systems** expired at the end of 2016. If you installed a small wind system in 2015 or 2016, file form 5695 with your taxes to claim the credit.

2:13 PM
5/8/2017

FEIQ Website

http://articles.extension.org/pages/72595/northeast-farm-energy-iq-curriculum

My contact info:
helsel@scarletmail.Rutgers.edu

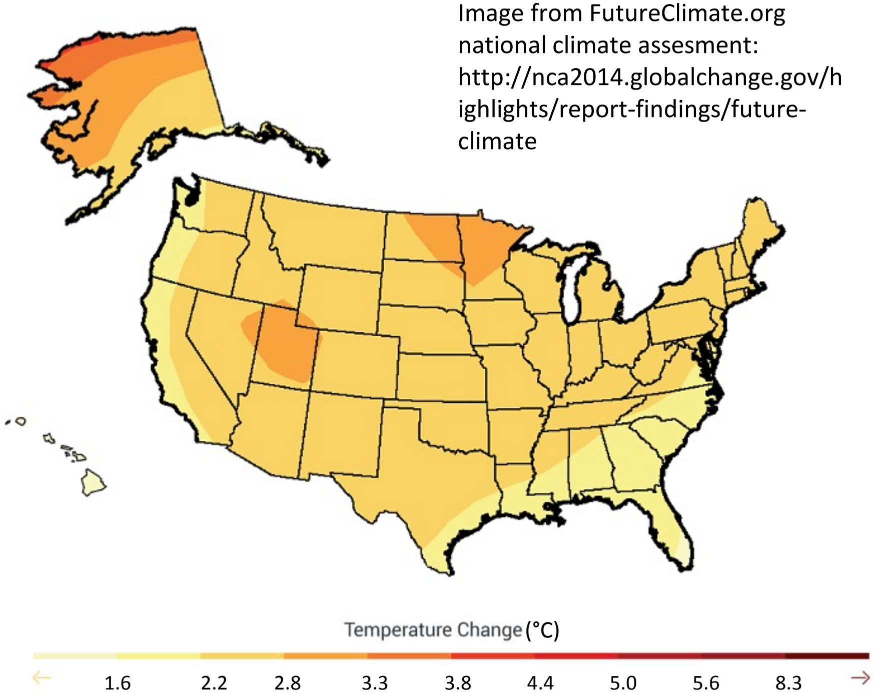
Energy Resilience in Farmstead Operations

Daniel Ciolkosz
Penn State Extension
Dept. of Ag & Biol. Engineering

Facility Design Criteria

- Future climatic conditions
- Future animal performance

Image from FutureClimate.org national climate assesment: http://nca2014.globalchange.gov/highlights/report-findings/future-climate



“Free” Energy – gravity, wind, sunlight

- Generation opportunities
  - “Islandizing” circuitry required if standalone operation is required
- Siting opportunities
  - Solar, Wind, Water, etc.

"Free" Energy: re-use

- Refrigeration heat recovery
- Well water pre-cooling
- Engine genset heat recovery

High Energy Performance

- Insulation
- Refrigeration
- Fans
  - "BESS" database for performance data (http://bess.illinois.edu/)
- Motors
  - High Efficiency models
  - "EC" (Electronically Commutated) for small motors
  - VSD/VFD Variable Speed Controllers
- Heat
  - High Efficiency furnaces, boilers, heat pumps

Fail safe modes

- Critical Systems passive or manual operation mode
- Backup/alternate power

Closing thoughts

- Anecdotally, energy resilience on farms is sometimes good, sometimes not so good.
- Some energy resilience measures are familiar, some are less so.
- We have the opportunity to work towards making farm energy resilience a deliberate choice rather than a happy coincidence.
- To grow your understanding of farm energy issues, check out the Farm Energy IQ curriculum posted on the e-extension website: http://articles.extension.org/pages/72595/northeast-farm-energy-iq-curriculum

The End…?

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- Please contact us with questions or comments!

  - Dan Ciolkosz: dec109@psu.edu
  - Zane Helsel: helsel@scarletmail.Rutgers.edu

Match Tractor and Equipment

Use pony engines or alternative gearing with large tractor pulling sprayer or similar

Gear Up/Throttle Down

Use highest gear and lowest RPMs in older tractors (no visible soot)

New Tractors—Constant Variable Transmission (CVT) Replaces Gear/Throttle

Photo credit: Margy Eckelkamp/Farm Journal Media

Table 1.2-13. Average daily production and total content of manure.

Animal type	Daily production	Manure % dry matter	Analysis units	N	P_2O_5	K_2O
Dairy cattle						
Lactating cows, liquid	13 gal/AU/day	<5	lb/1,000 gal	28	13	25
Lactating cows, solid	111 lb/AU/day	12	lb/ton	10	4	8
Dry cow	51 lb/AU/day		lb/ton	9	3	7
Heifer	60 lb/AU/day		lb/ton	10	3	7
Calf	80 lb/AU/day		lb/ton	10	3	4
Veal	7 gal/AU/day	2	lb/1,000 gal	19	13	25
Beef cattle						
Cow and calf	90 lb/AU/day	12	lb/ton	11	7	10
Calf	90 lb/AU/day	12	lb/ton	11	7	10
Finishing cattle	65 lb/AU/day	8	lb/ton	14	5	8
Swine						
Farrow to wean (includes sows)	11 gal/AU/day	2.5	lb/1,000 gal	18	18	11
Nursery	14 gal/AU/day	1.5	lb/1,000 gal	19	8	14
Wean to finish	5.5 gal/AU/day	4	lb/1,000 gal	37	23	21
Grow to finish	7 gal/AU/day	4	lb/1,000 gal	31	24	22
Swine, anaerobic lagoon	These figures apply only to a treatment lagoon.					
Supernatant	—	0.25	lb/1,000 gal	2.9	0.6	3.2
Sludge	—	7.6	lb/1,000 gal	25	23	63
Sheep/Goats	40 lb/AU/day	25	lb/ton	23	8	20
Horse	55 lb/AU/day	20	lb/ton	12	5	9
Poultry						
Layer (364 d)[1]	26 lb/AU/day	41	lb/ton	37	55	31
Pullet (126 d)[1]	48 lb/AU/day	35	lb/ton	43	46	26
Light broiler (44 d)[1]	22 lb/AU/day	66	lb/ton	79	62	42
Heavy broiler (57 d)[1]	20 lb/AU/day	75	lb/ton	66	63	47
Turkey (tom) (123 d)[1]	13 lb/AU/day	60	lb/ton	52	76	42
Turkey (hen) (88 d)[1]	11 lb/AU/day	65	lb/ton	73	88	46
Duck (dry)	110 lb/AU/day	27	lb/ton	21	26	15
Duck (wet)	13 gal/AU/day	5	lb/1,000 gal	33	23	16

Note: When possible, have manure analyzed. Actual values may vary over 100 percent from averages in the table.

1. Typical production days.

Source: 2013-2014 PSU Agronomy Guide

Table 1.2-14. Manure nitrogen availability factors for use in determining manure application rates based on planning conditions.

A. Current Year

To use this table, find the ***planned manure application season*** in the left column, then move to the right in that row and select the target crop utilization. Continue to the right in that row to find the ***nitrogen availability factor*** for the ***planned manure application management.***

The manure nitrogen availability factor is the fertilizer equivalence of the manure N or the lb of fertilizer N equivalent per pound of total manure N. For example, if the N Availability Factor = 0.50, effectively there is the equivalent of 0.50 lb of fertilizer N for every pound of total N in the manure.

Planned manure application season	*Planned manure target crop utilization*	*Application management*	*Nitrogen availability factor[1]*: *Poultry manure*	*Swine manure*	*Other manure*
Spring or summer	Spring utilization by grass hay and small grains. Summer utilization by corn, other summer annuals, and grass hay.	Incorporation the same day	0.75	0.70	0.50
		Incorporation within 1 day	0.50	0.60	0.40
		Incorporation within 2–4 days	0.45	0.40	0.35
		Incorporation within 5–7 days	0.30	0.30	0.30
		Incorporation after 7 days or no incorporation	0.15	0.20	0.20
Early fall[2,3]	Early spring utilization by small grains, small grain silage, and grass hay, including the winter crop in a double-crop system	Incorporated less than 2 days	0.50	0.45	0.40
		Incorporated 3–7 days	0.30	0.30	0.30
		Incorporated more than 7 days or no incorporation	0.15	0.20	0.20
Early fall Additional N available to the summer crop in a double-crop system from manure applied in the fall for the winter crop (above)[2,4]	Summer utilization by the second crop, corn or other summer annuals, in a double-crop system	All methods of incorporation	0.15	0.20	0.20
Early fall with a cover crop not harvested and used as a green manure[2]	Summer utilization by corn, other summer annuals, and grass hay	Incorporated less than 2 days	0.45	0.40	0.35
		Incorporated 3–7 days	0.25	0.25	0.25
		Incorporated more than 7 days or no incorporation	0.15	0.20	0.20
Early fall with no cover crop[2]	Summer utilization by corn, other summer annuals, and grass hay	All methods of incorporation	0.15	0.20	0.20
Late fall or winter[5]	Spring utilization by small grains and grass hay	All situations	0.50	0.45	0.40
	Following summer utilization by corn or other summer annuals	No cover crop	0.15	0.20	0.20
		Cover crop harvested for silage	0.15	0.20	0.20
		Cover crop used as green manure	0.50	0.45	0.40
Grazing	Late spring through early fall grazing	Manure deposited more or less continuously by grazing cattle	—	—	0.20
	Year-round grazing	Manure deposited more or less continuously by grazing cattle	—	—	0.30

1. Multiply this factor times the manure N content to estimate the manure N available for the planning conditions.
2. Early fall would be when it is still warm enough for plant growth and microbial activity to continue (soil temperature >50ºF at 2 inches).
3. When manure is applied in the early fall to the winter crop in a double-crop system, use these factors to determine the N available to the winter crop.
4. Use these factors to determine the N available from the fall application in a double-crop system to the summer crop. These factors would be applied to the same manure application that was used for the winter crop (see footnote 3 above).
5. Late fall and winter is when it is so cold that there is no plant growth or microbial activity (soil temperature <50ºF at 2 inches).

Source: 2013-2014 PSU Agronomy Guide

Table 1.2-15. Factors for calculating manure nitrogen availability based on time of application, incorporation, field history, and manure analysis with ammonium and organic N fractions. Recommended for all manures, but required for atypical or treated manures.

The manure nitrogen availability factor is the fertilizer equivalence of the manure N or the lb of fertilizer N equivalent per pound of ammonium or organic manure N. For example, if the ammonium N Availability Factor = 0.80, effectively there is the equivalent of 0.80 lb of fertilizer N for every pound of ammonium N in the manure. Likewise, if the organic N Availability Factor = 0.35, effectively there is the equivalent of 0.35 lb of fertilizer N for every pound of organic N in the manure.

TOTAL MANURE N

AMMONIUM N ANALYSIS

Spring/summer

For spring utilization by small grains and grass hay and summer utilization by corn, other summer annuals, and grass hay

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
Immediately	0.90	0.80	0.80
1	0.80	0.60	0.60
2–4	0.60	0.40	0.40
5–7	0.40	0.20	0.20
>7	0.20	0.10	0.10

Early fall[3]

For fall and spring use by grass hay, small grains, small grain silage

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
0–2	0.80	0.60	0.40
3–7	0.50	0.30	0.20
>7	0.20	0.10	0

For following summer utilization by a summer crop following a non-harvested cover crop used as a green manure

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
0–2	0.45	0.35	0.35
3–7	0.20	0.15	0.15
>7	0	0	0

For following summer utilization by a summer crop following a harvested winter crop or no winter crop

No ammonium -N credit

Late fall/winter[4]

For following summer utilization by a summer crop following a harvested winter crop or no winter crop

No ammonium -N credit

For spring use by grass hay or small grains, or summer use by corn or summer annuals *with green manure cover crop*

	Poultry[2]	Other	Compost
All Situations	0.60	0.50	0.50

ORGANIC N ANALYSIS (total N – ammonium N)

Organic N decomposed during year applied

	Poultry	Swine	Other	Compost
Summer crop	0.60	0.50	0.35	0.10
Winter crop	0.40	0.30	0.25	0.10

Additional organic N available to the summer crop in a double-crop system from manure applied in the fall for the winter crop (above)

	Poultry	Swine	Other	Compost
Summer crop	0.30	0.25	0.20	0.10

Organic N decomposed from past applications

Manure applied	Manure	Compost
1 yr ago	0.12	0.05
2 yrs ago	0.05	0.02
3 yrs ago	0.02	0.01
4 yrs ago	0.02	0.01
5 yrs ago	0.01	0.01

1. Mechanical incorporation or incorporation by 0.5 inch of rain.
2. Increase these factors by 0.2 after one day for very liquid manures (<5 percent solids) to account for soaking-in on application.For spring use by grass hay or small grains, or summer use by corn or summer annuals with green manure cover crop
3. Early fall would be when it is still warm enough for plant growth and microbial activity to continue (soil temperature >50°F at 2 inches).
4. Late fall and winter is when it is so cold that there is no plant growth or microbial activity (soil temperature <50°F at 2 inches).

Adapted from Klausner and Bouldin, Cornell University; Jokela, University of Vermont; and Sims, University of Delaware.

Source: PSU Agronomy Guide

Pumps

- Types
  - Centrifugal-surface waters
  - Submersed turbines-deepwell
  - Others
- Power units
  - Electrical
  - Diesel