

Dairy Heifer Diets, Manure Management, and Runoff Phosphorus

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Manure is a valuable resource

It can provide nutrients for crop production...



...but also for algae and aquatic weeds

Eutrophication
(P the limiting nutrient)

Management Factors and Phosphorus Runoff Losses

- Manure application method
 - Surface-applied or incorporated in soil
- Application rate
- Timing of application
- Manure P content (dietary P level)
- Soil test P level

Management Effects on P Loss: Manure Application Method/Incorporation

- Incorporation by tillage or injection
- Effect of tillage incorporation of manure on runoff losses
 - Decreased dissolved reactive P (DRP) concentration
 - Soil/sediment loss often increased
 - Total P? +/-

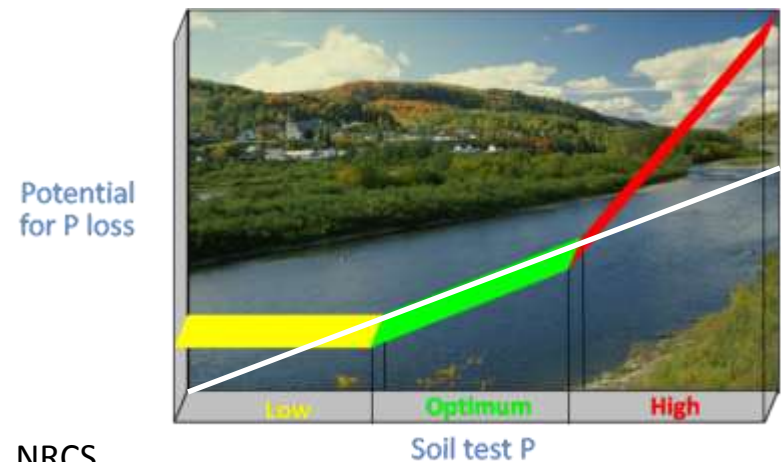


Management Effects on P Loss: Application Rate

- Direct P loss from applied manure
 - Higher rate → More P loss
- Build up of soil P from excess application rate of manure (or fertilizer P)
- Soil test P → Runoff P
 - Can be soil-specific
 - Can be curvilinear or linear relationship



Soil P Increases, so does Runoff P.



Management effects on P losses: Manure P Content/Dairy Dietary P

- Lactating cows:
 - No improved animal performance with P supplementation above NRC recommended levels (Wu et al., 2000)
 - Excess dietary P increases manure P content
 - Land application of high P manure increases runoff P (Ebeling et al., 2002)
- What about dairy heifers?
 - P supplementation increased manure P content but not animal performance (Bjelland et al., 2011)
 - Runoff P from applied manure??



Three Experiments: Dairy heifer manure and typical central Wisconsin soil

1. Application method and manure P level
 - Manure surface-applied vs incorporated (or none)
 - Manure from heifers fed diets +/- supplemental P
2. Application rate and manure P level
 - Surface-applied manure at rates equivalent to 15 and 30 ton/acre
 - Manure from heifers fed diets +/- supplemental P
3. Soil test P levels without applied manure
 - Low to excessive (11 to 79 ppm Bray P1)
 - Variable soil test P from different past fertilizer P and manure application rates

Experimental Methods:

Runoff from simulated rain with runoff pans

- Rainfall simulator with single nozzle (National P Project design)
- Metal pans (40 x 8-inch x 2-inch soil depth) at 5% slope
- Withee silt loam soil
- Collected runoff for 30-min after start of runoff (rain intensity of 2.75 in/hour)
- Two rain/runoff events
 - 24 hours after manure application
 - 3 or 4 days later
- Runoff analysis
 - Runoff quantity/volume
 - Total and volatile (organic) solids, or sediment, concentration
 - Total P and dissolved reactive P (DRP) concentration



Manure Source

- Manure from dairy heifers in ongoing study (1000-lb avg.)
- Heifer diets
 - P-supplemented (0.38%)
 - Non-supplemented (0.32%)
- Sawdust-bedded manure (18-21% DM)
- Manure P from P-supplemented diets (vs non-supplemented)
 - 20-25% higher total P
 - 60-100+% higher water-extractable P



Results

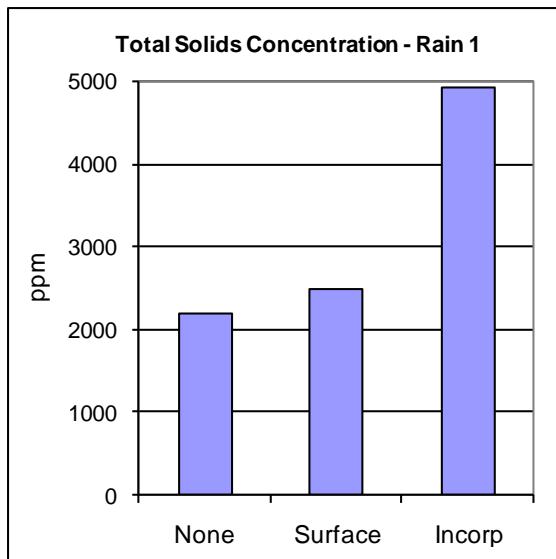
- Manure application method: Incorporation vs surface
 - Manure application rate
 - Manure P/Dietary P level
 - Soil test P
-
- Focus on runoff P concentrations; similar treatment effects on P load/total loss (concentration x runoff volume)



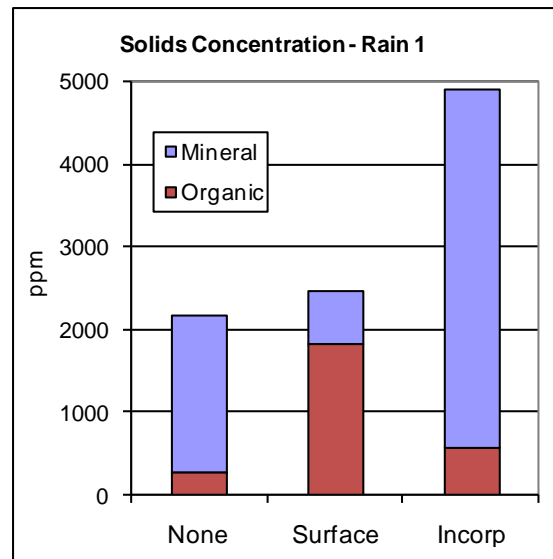
Manure Incorporation Effect on Runoff Solids Concentration

(Exp. 1, Average across diet P and STP levels)

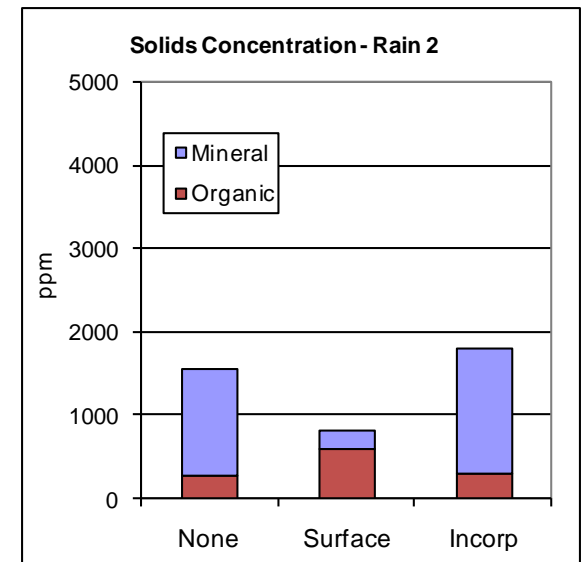
Total Solids – Rain 1



Mineral and Organic Solids – Rain 1



Mineral and Organic Solids – Rain 2

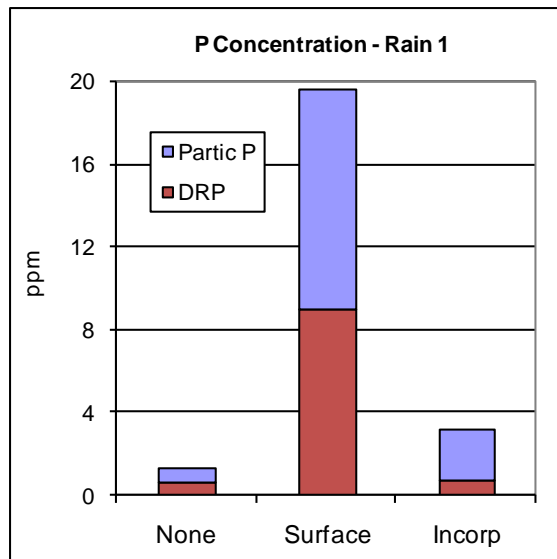


- Total solids: Incorporated > Surface (manure as mulch)
- Organic (volatile) solids: Surface > Incorporated
- Rain 2 < Rain 1

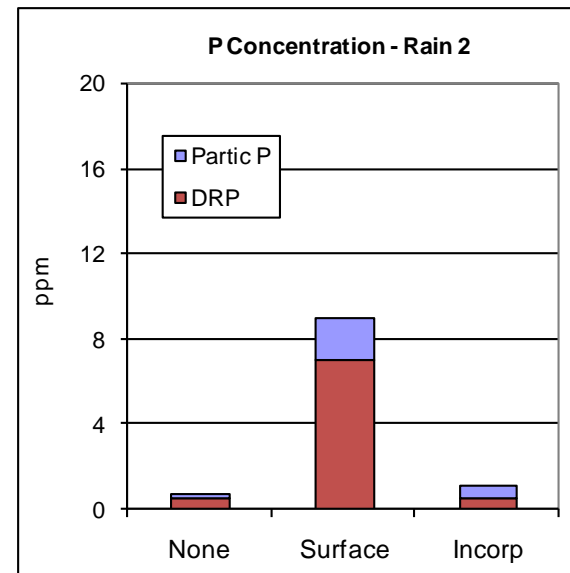
Manure Incorporation Effect on Runoff Phosphorus Concentration

(Exp. 1, Average across diet P and STP levels)

Rain 1



Rain 2

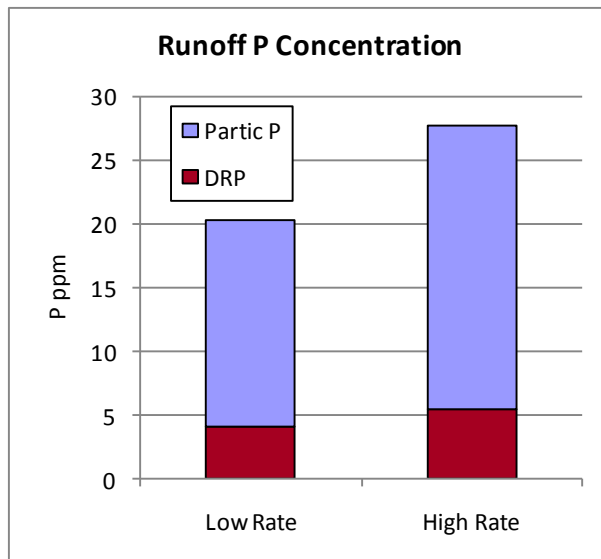


- Dissolved (DRP) and Total P: Surface >> Incorporated
- Dissolved P (DRP): Incorporated = No Manure
- Rain 2 < Rain 1, but DRP/TP ratio: Rain 2 > Rain 1

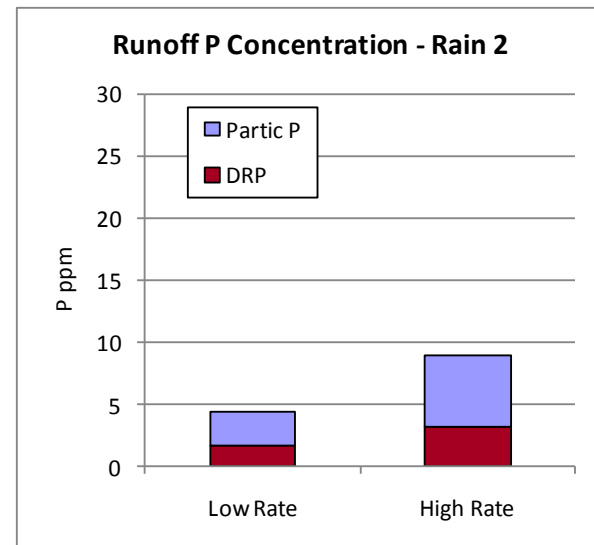
Manure Rate Effect on Runoff P Concentration

(Exp. 2, Average across diet P levels)

Rain 1



Rain 2

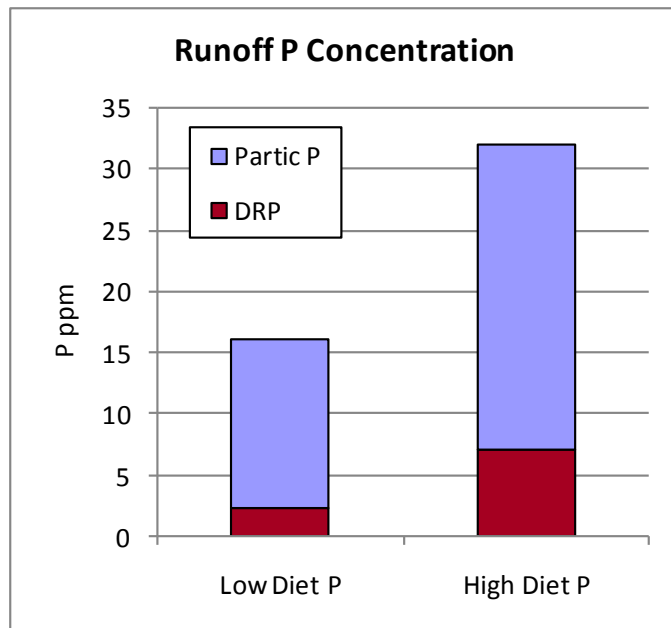


- Dissolved (DRP) and Total P: High rate > Low rate
- Rain 2 < Rain 1

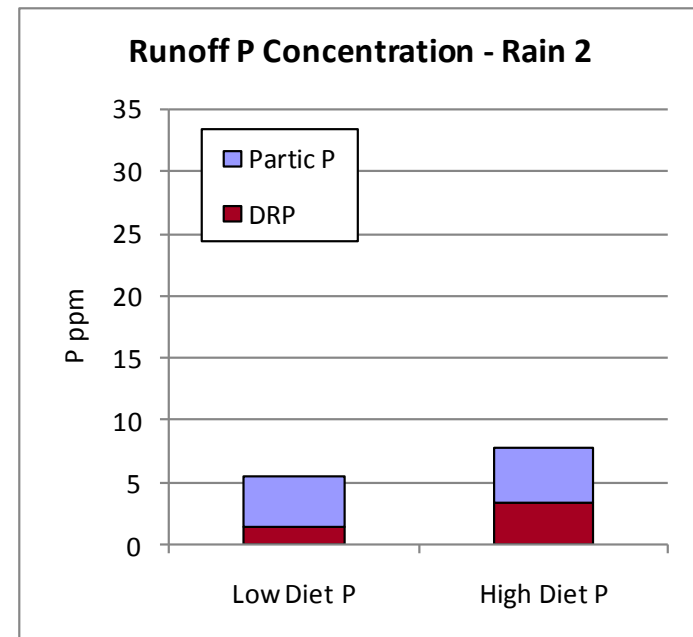
Dietary P/Manure P Effect on Runoff P Concentration

(Exp. 2, Average across manure rates)

Rain 1

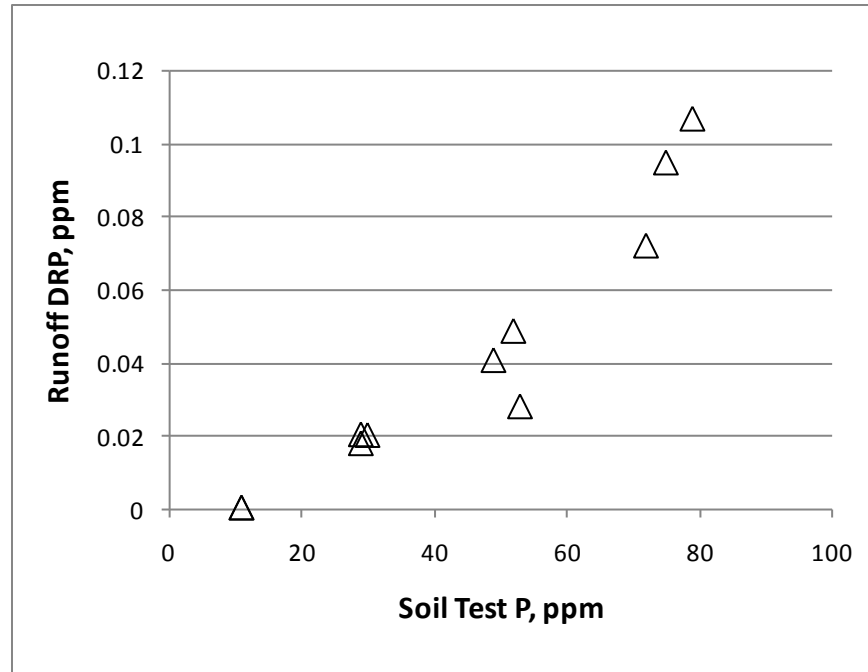


Rain 2

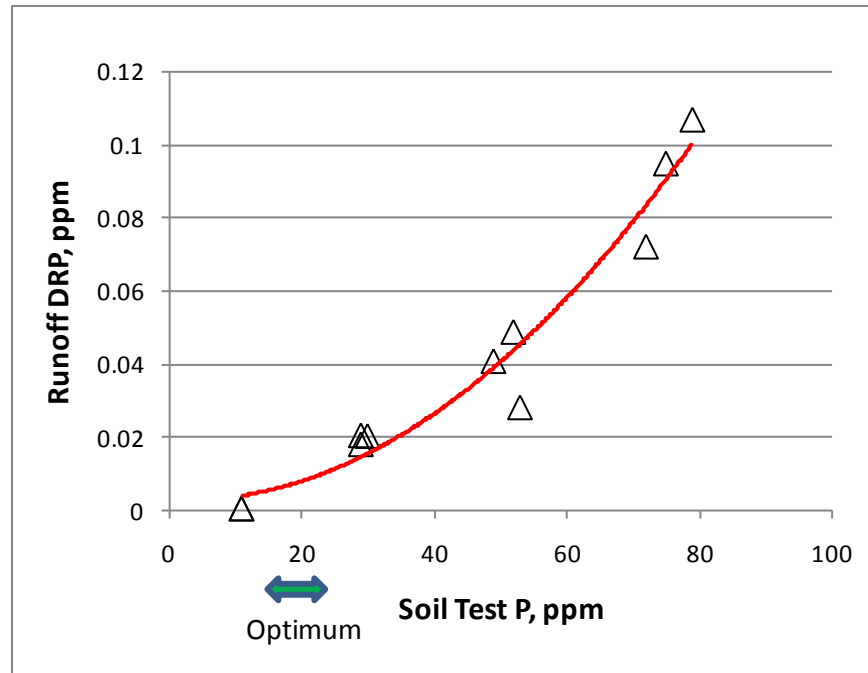


- Dissolved P (DRP): High Diet P = 3 x Low Diet P
- Total P: High Diet P = 2 x Low Diet P
- Rain 2 < Rain 1, but DRP/TP ratio: Rain 2 > Rain 1
- Exp. 1: Dissolved P: High Diet P > Low Diet P; Total P: High Diet P = Low Diet P

Soil Test P Effect on Runoff P Concentration



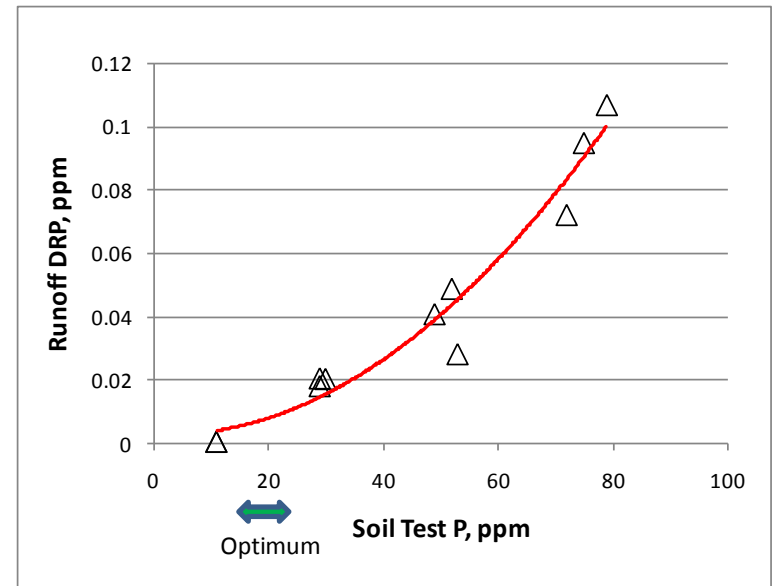
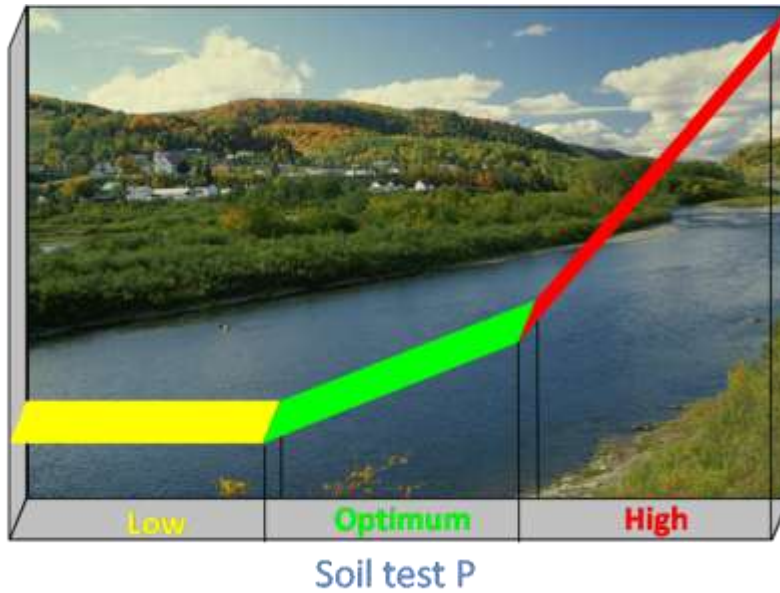
Soil Test P Effect on Runoff P Concentration



- Runoff dissolved P (DRP) increased with increasing soil test P
- Greater rate of increase at excessive soil test P
- DRP concentration: High STP (nonmanured) << surface manure

Soil Test P Effect on Runoff P Concentration

Potential for P loss



Summary of Results:

Effects on Runoff Concentrations

- Manure incorporation (vs. surface)
 - Increased total solids concentration
 - Decreased organic (volatile) solids concentration
 - Decreased total and dissolved P concentration
- Increased manure application rate
 - Increased total and dissolved P concentration
- P supplementation of dairy heifer diet
 - Increased manure P content
 - Increased total and dissolved P concentration

Summary of Results (cont.)

- Soil test P
 - Dissolved P concentration **increased** with increasing soil test P (curvilinear)
 - P concentration much less than from applied manure
- Successive rain/runoff events
 - Runoff P concentration **decreased** in second event

Summary:

Practices to minimize runoff P loss

- Incorporate manure into soil
 - But control erosion to avoid increased sediment and particulate P loss
- Limit application rate
 - Agronomic (soil test P-based) or crop P removal
- Avoid unnecessary dietary P supplementation
 - Improves whole-farm P budget and long-term nutrient management
 - Decreases land area needed for P-based manure application
- Manage soils to prevent excessive soil test P

