

Land Application of Drill Cuttings

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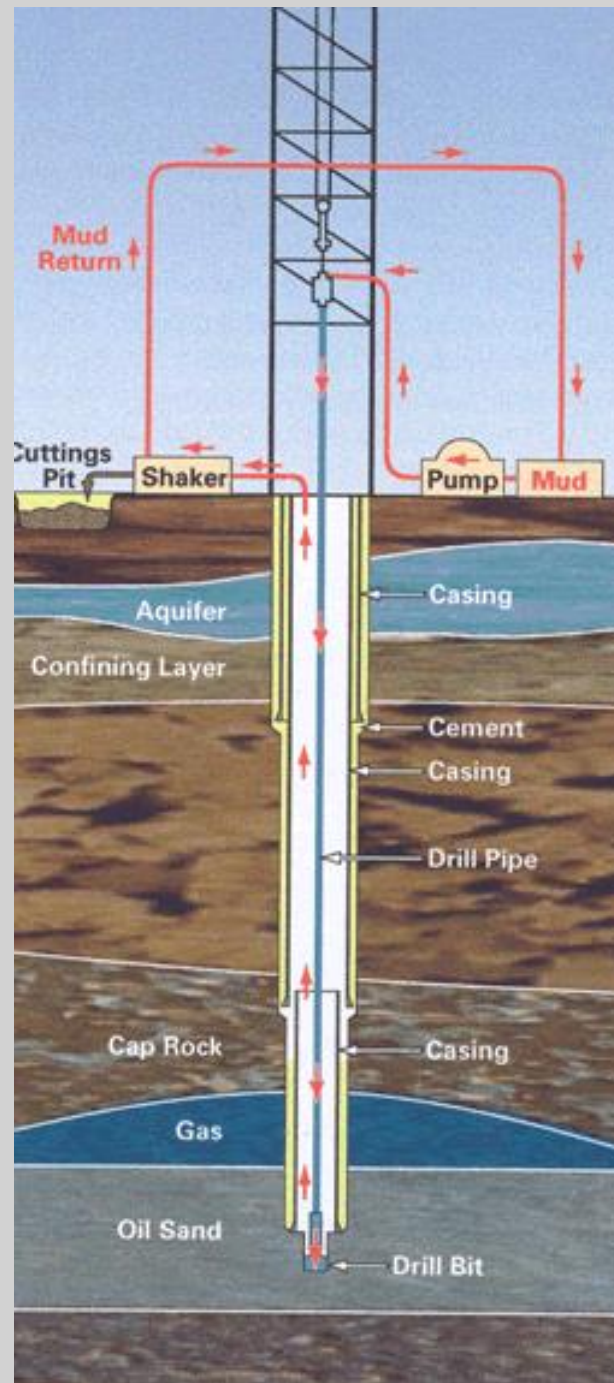


Drilling Mud is NOT Fracking Fluids

- All wells produce drilling mud
 - Mud is a by-product of drilling not fracking
- All wells are not fracked

*Penn, C., and H. Zhang. 2013. An introduction to the land application of drilling mud in Oklahoma. OSU Fact Sheet, WREC-102. Oklahoma State Univ. Coop Ext. Service, Stillwater, OK.





Types of mud

- Water (WBM) and oil based (OBM)
 - WBM uses water as solvent
 - OBM uses diesel as solvent
- Have different characteristics for different purposes in drilling
 - Varies between well, region, and operator
- Typically, WBM is used in the vertical portion of the hole and OBM is used in the curve and horizontal portions

Disposal of drilling mud



WBM



OBM



Risks: WBM

- Salinization of soils
 - Excess salts: reduces the ability of the plant to uptake water.
 - Approximated by EC
 - Remedy: leach out with natural rainfall and time
- Sodic soils
 - excess Na: poor drainage, poor structure little growth
 - Remedy: gypsum + water

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

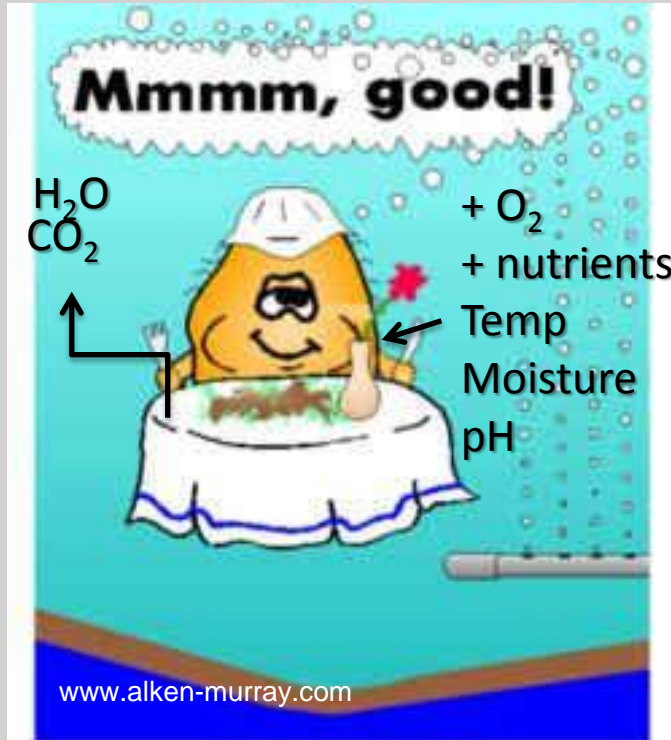
Saline/Sodic Soils



Risks: OBM

- TPH toxicity to plants
 - Not a long term risk
 - TPH degraded into CO_2 and H_2O through soil microorganisms
 - Optimize conditions: temp, pH, nutrients, oxygen
 - “Bio-Treatment”
 - Salinization and Sodidity
 - Not as much of a risk as for WBM

Excessive TPH



Metals

- WBM: low to no risk
 - Survey of 90 different WBM samples showed none with excessive metals concentrations
- OBM: low risk
 - Mud survey showed few samples with elevated metals
 - If drilling in areas known to contain geologic material high in certain metals, then mud should be tested
 - Example: Norman drinking water

Rules and Regulations: OK Corporation Commission

- Max 8% slopes
- At least 12 inches of acceptable soil texture
- Must maintain buffer zones (property boundaries, perennial streams, ponds, water wells, etc.)
- E.C. Less than 4,000 μS and E.S.P. less than 10% in receiving soil
- Depth to bedrock, 20 inches for WBM, 40 inches for OBM
- No water table within top 6' of Soil Profile
- WBM may be re-spread after 3 years has passed and Soil test requirements met
- OBM sites can not be re-used for WBM or OBM

Permissible Loading

- Use Most Limiting Factor Calculations from OK Corporation Commission
 - Must not exceed loading rates
 - 6,000 lbs/ac TDS
 - 3,500 lbs/ac Cl⁻
 - 40,000 lbs/ac TPH
 - 200,000 lbs/ac Dry Weight (For Solids)

Handling of Mud

- OBM is spread only as a solid

– Must be mixed with bulking agent at a 3 parts agent to 1 part OBM ratio



Handling of Mud

- WBM is spread both in liquid and solid form



Economics for typical wells

County	WBM (barrels)	OBM (barrels)	Acres	WBM value (\$)	OBM value (\$)	Total value (\$/acre)
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Is it worth it?

Alfalfa	7480	0	40	3740	0	93
Noole	21000	0	80	10500	0	131
Ellis	13870	7520	70	6935	7520	207

Canadian	16060	11700	40	8030	11700	493
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Roger Mills	16540	12100	70	8270	12100	291
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Washita	17490	9010	60	8745	9010	296
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Grady	18850	5900	120	9425	5900	128
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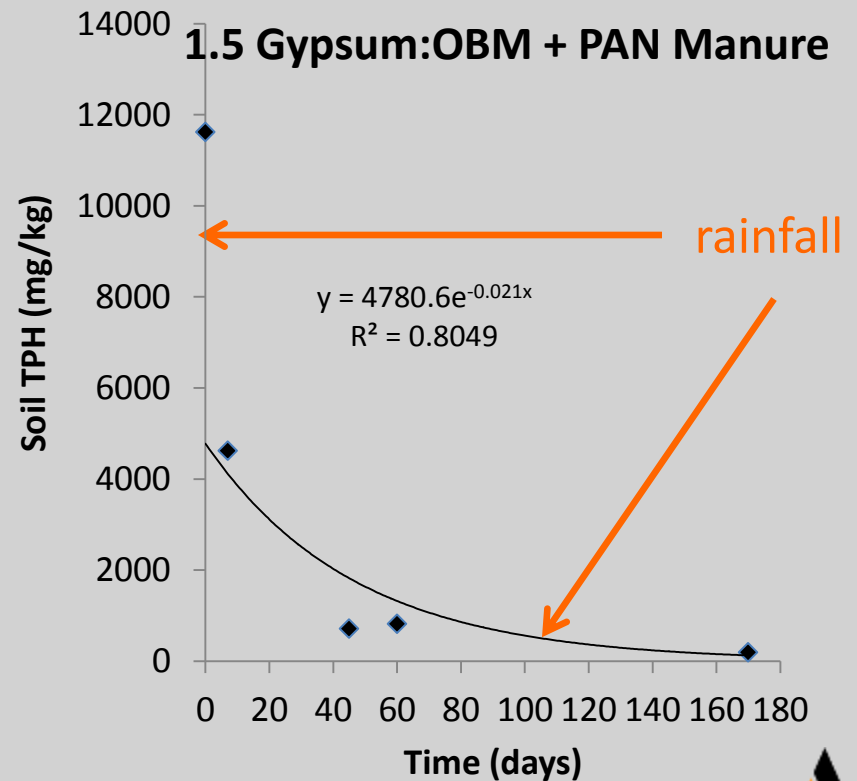
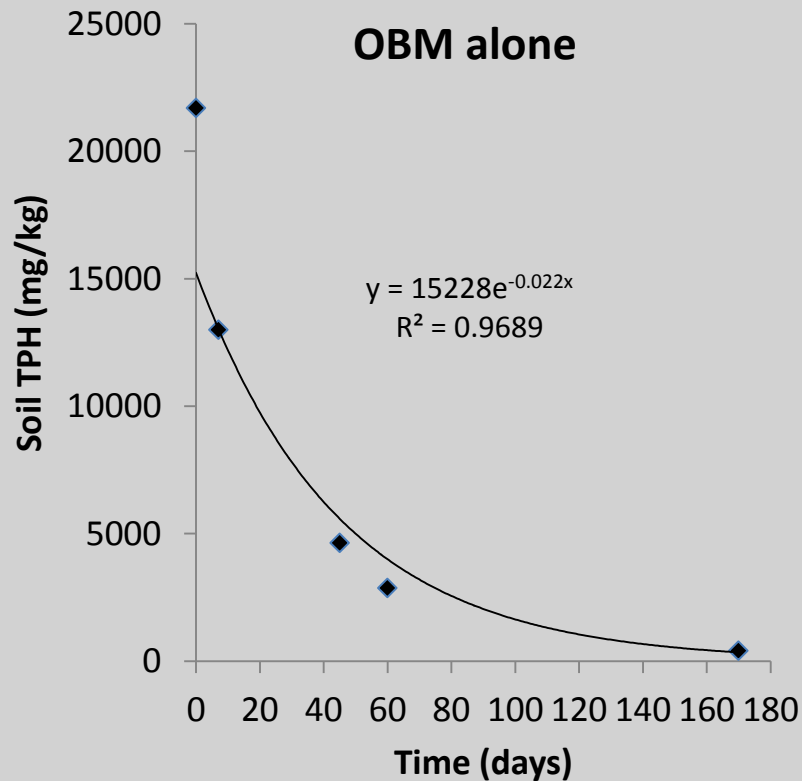


OBM field plots: TPH degradation

- 3 bulking agents
 - Gypsum, caliche, and lime
- 3 ratios of bulking agent:OBM
 - 3:1, 1.5:1, and 0 (mud alone)
- Manure amendment applied to mud alone and gypsum bulked
 - Plant available N rate (PAN) and 1.5 PAN

TPH Degradation

Day 178 TPH changed from 7200 mg kg⁻¹ to 730 mg kg⁻¹



Forage Yield

You Win!!!



*Penn C.J., A.H. Whitaker, and J.G. Warren. 2014. Surface application of oil-base drilling mud mixed with gypsum, limestone, and caliche. *Agronomy J. In Print.*



OBM Conclusions

- TPH degrades quickly by itself
- No need for “additives”
- Metals?
- Relatively low risk of long term negative impact
 - TPH testing at OSU
 - Only 2 water samples in 1.5 years had TPH levels above zero.

WBM Research

- Impact of salts from WBM on wheat and grass
 - Evaluate application timing and rate
 - Lahoma: wheat and grass
- Added WBM at two different rates
 - Evaluated application timing

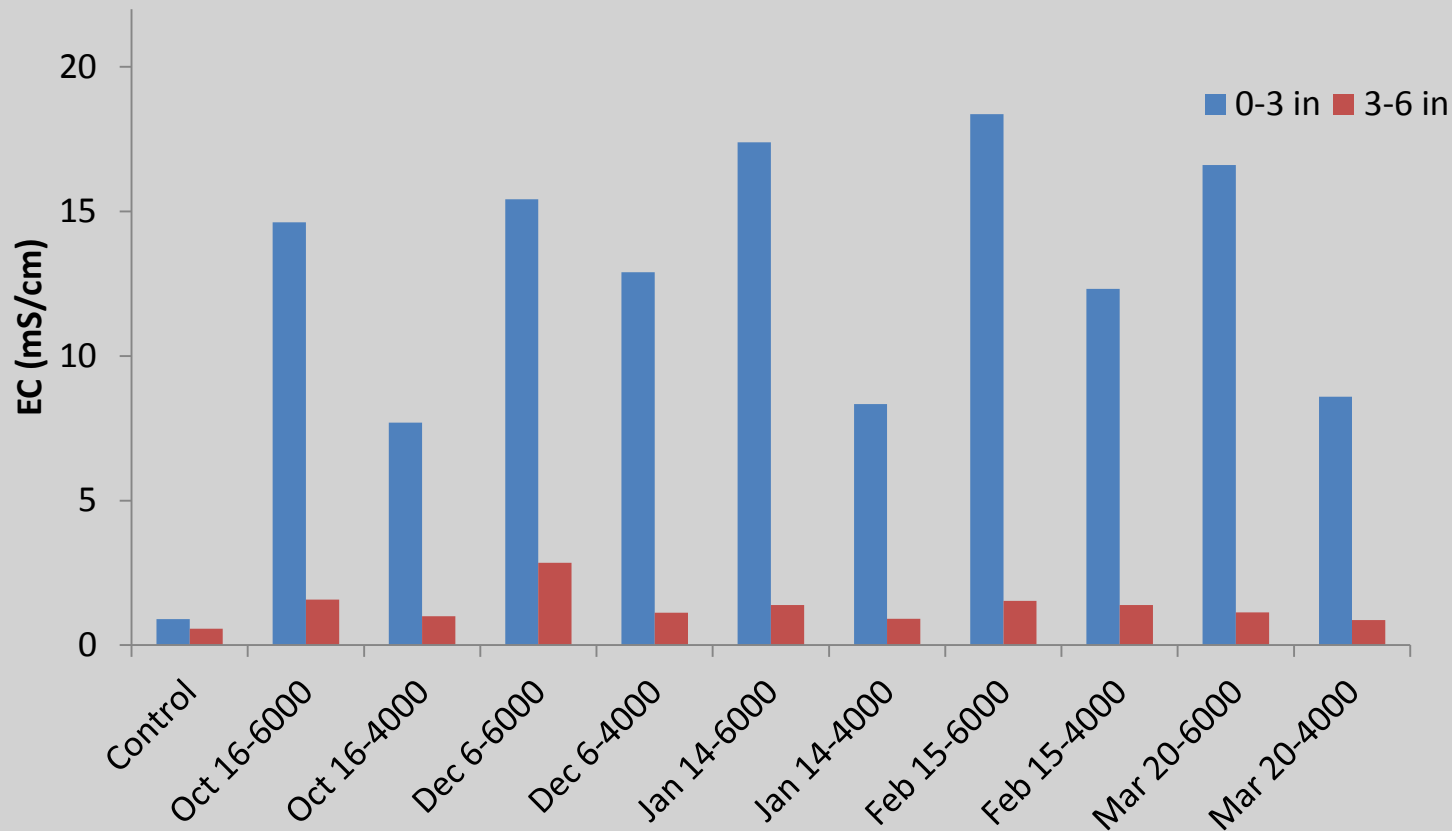


Penn, C.J., and J. G. Warren. 2014. Application of water-base drilling mud to winter wheat: impact of application timing on yield and soil properties. Oklahoma State Cooperative Extension. CR-2272.

Application of WBM: 4000 and 6000 lbs of TDS/acre



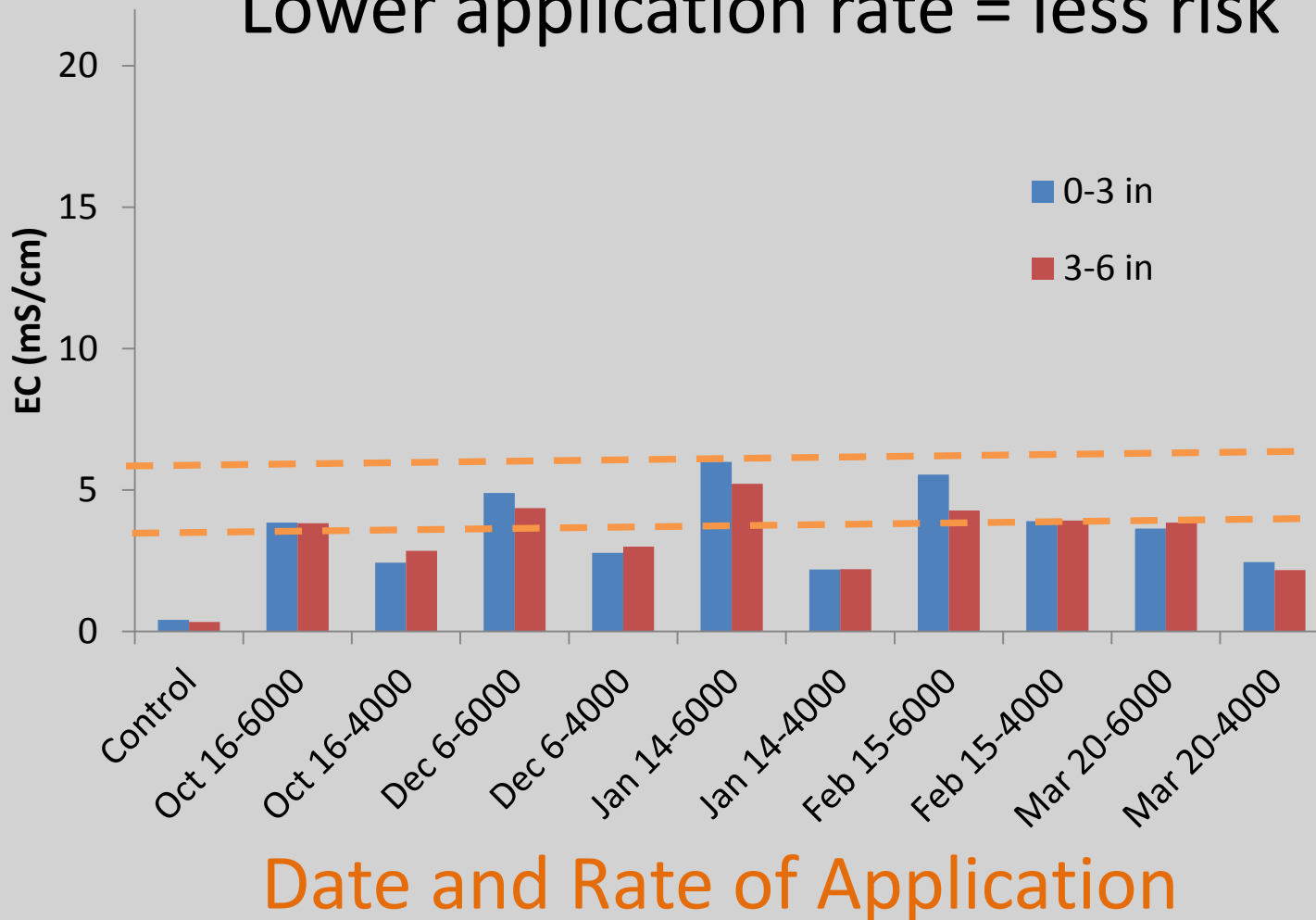
EC: Day 0 (after application)



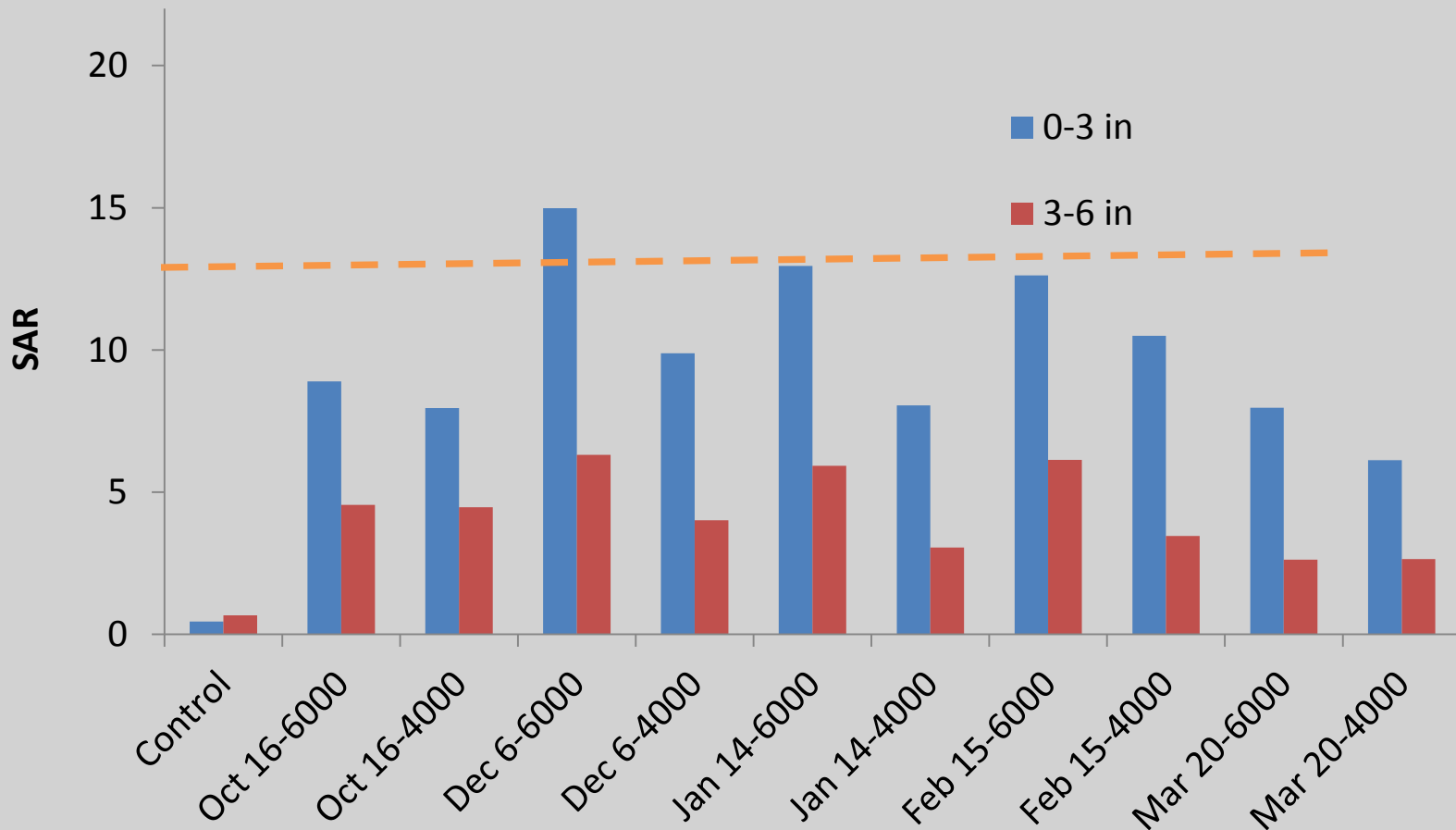
Date and Rate of Application

EC: August 28th, 2013

Lower application rate = less risk



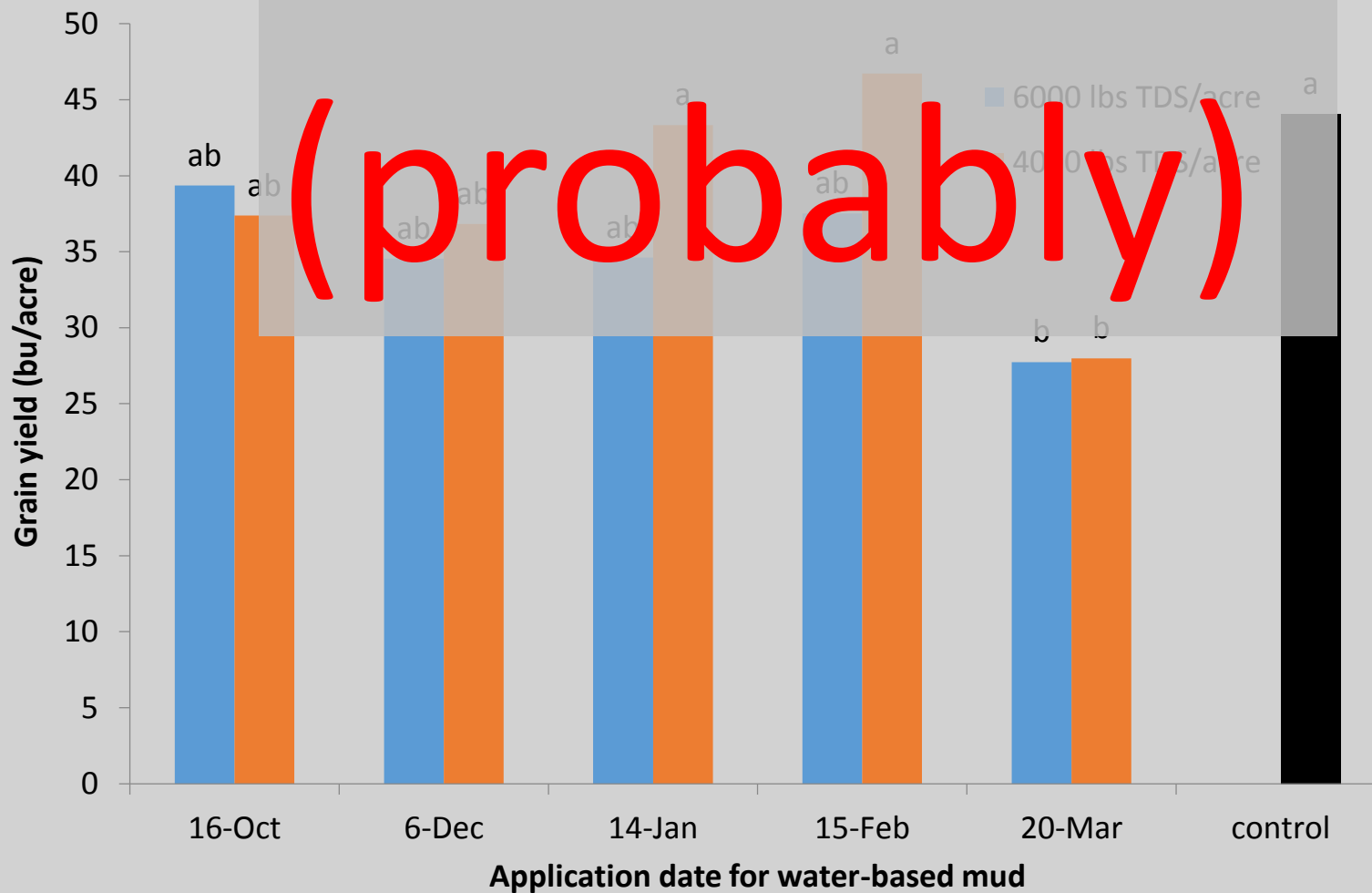
SAR: August 28th, 2013



Date and Rate of Application

Wheat grain yield

You Win!!!



(probably)

WBM Conclusions

- Greater risk of causing long term damage compared to OBM
 - i.e. salts don't degrade
- Soil texture is double edged sword
 - Heavy texture can handle more, but decreases more slowly in SAR
- Rainfall is critical
- If applied correctly, expect no long term soil damage
- Apply to grass when dormant