Alternatives for Managing Wheat Straw

Assessing Soil Water Storage, Nutrient Status and Removal, and Weed Management

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SITES One and Two

Cooperators: West aspect and East aspect

Dave and Dwelley Jones, Walla Walla County Producers

SITE Three: Cook Agronomy Farm, Pullman

Burning wheat residues

Incentives

1. facilitating the establishment of the next crop;
2. decreasing incidence of weeds and soil-borne disease;
3. decreasing nutrient (e.g. N) tie-up by decomposing cereal residues; and
4. positive response of crop growth, yield and economic return.

Burning wheat residues

***Project Objectives:* identify and economically assess effects of straw residue management by documenting:**

1. soil water storage;
2. nutrient status and removal;
3. several troublesome grassy weeds; and
4. conveying project findings through electronic and print media, extension field days, conferences and research site tours.

Key findings

- *Soil water retention.*
  - Water retention under the direct bale treatment was numerically lower than the two burn treatments and full residue retention treatment.
  - No statistical difference was shown among treatments. Relatively high precipitation may have nullified any beneficial effects of soil cover over removal by burning or direct bale.
  - It is expected that soil cover by providing protection from wind and shading, water loss by evaporation would be minimized under full residue cover vs burn and to a lesser extend direct bale.

Key findings

- 60% to 90% of the straw biomass is lost as smoke and wind-blown ash particulates
- 10% to 50% of the biomass straw is lost as smoke and wind-blown ash particulates under the windrow burn system.
- The simulated windrow system of this trial retained three-fold more ash residue than the full burn system.

Key finding

- Potassium loading from ash increased exchangeable potassium to seven (7) inches.
- Potassium mining under direct bale decreased exchangeable potassium to ten (10) inches
  - Most apparent in Walla Walla Loam
- Phosphorus loading from ash increased exchangeable fraction of phosphorus to a depth of three (3) inches.

More on Potassium

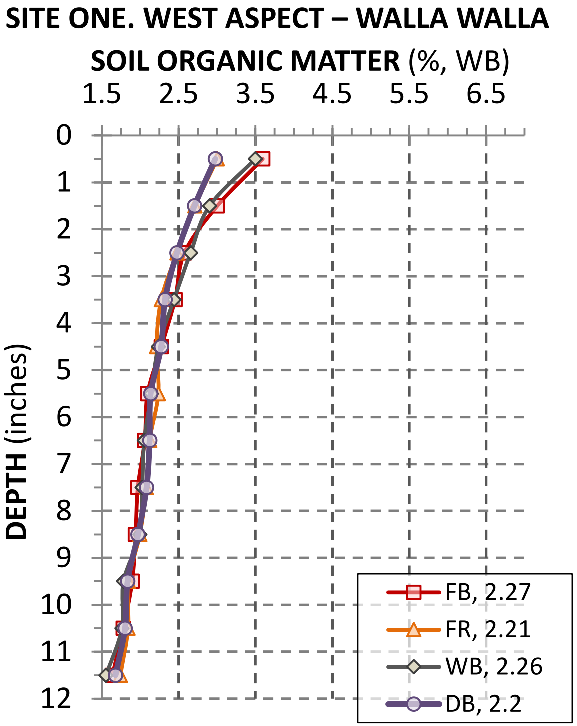
- Nutrients that concentrate in the soil cover as ash readily leach into the upper soil profile.
- Our findings point to significant changes in exchangeable potassium, where ash serves as a source of solubilized potassium that can very efficiently enter the cation exchange complex.
- We observed a significant treatment effect to a depth of four to seven inches at the Walla Walla sites. Further evidence supporting this observation is the significantly lower exchangeable potassium concentrations under the direct bale system, where we calculate that a range of 65 to 117 Lb/A of potassium (K2O) is removed from the soil profile.

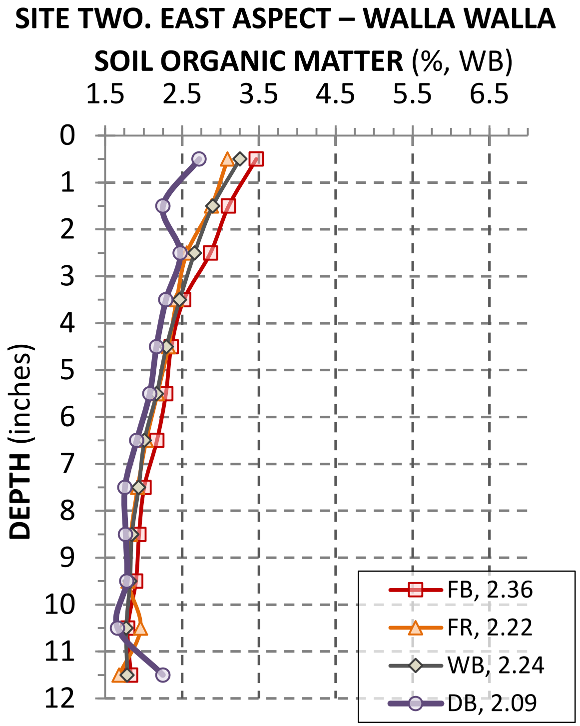
Key findings

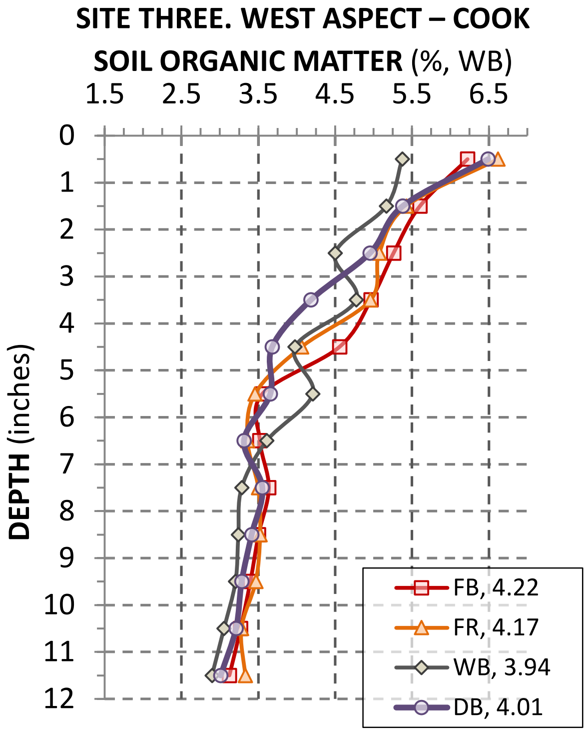
- Partial enterprise budget analysis
  - simulated direct bale treatment provides the largest average net return, \$526/A, (\$520/A to \$532/A) over the average net return for full the residue retention treatment of \$399/A, (\$395/A to \$403/A)

Site Descriptions. Soil Organic Matter

- Soil with high organic matter content has higher pH and nutrient buffering capacity
- Clay content affects nutrient buffering capacity



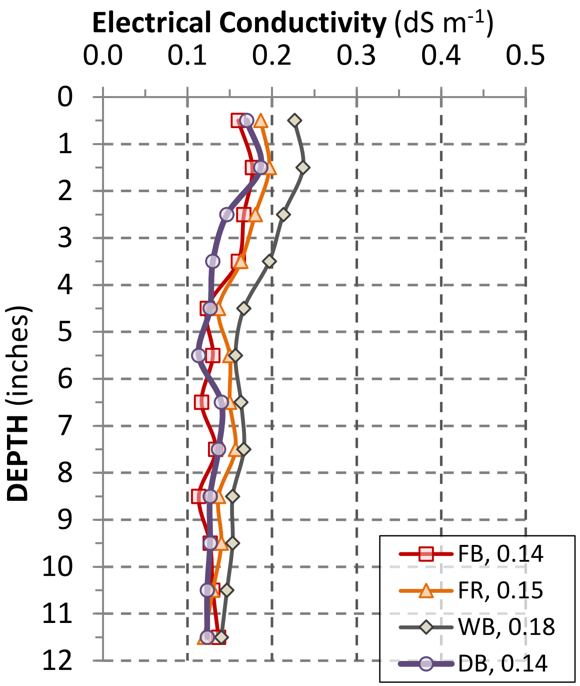




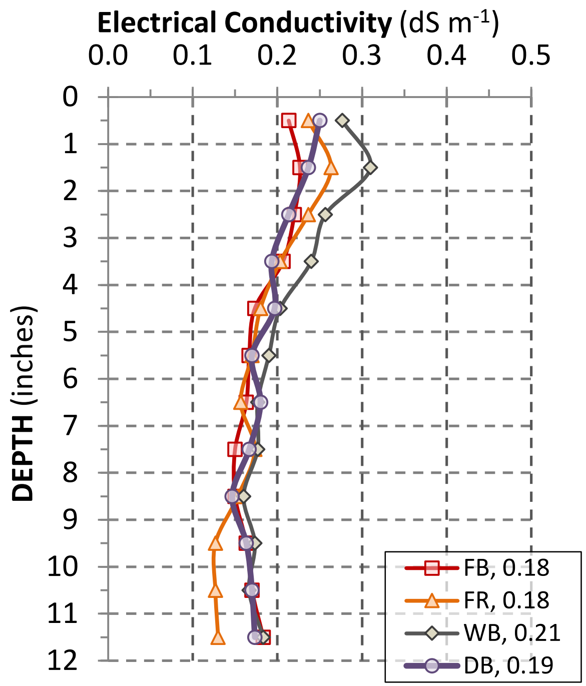
Site Descriptions. Electrical Conductivity

Concentrated ash under windrow burn significantly alters EC of surface soils with lower nutrient buffering capacities

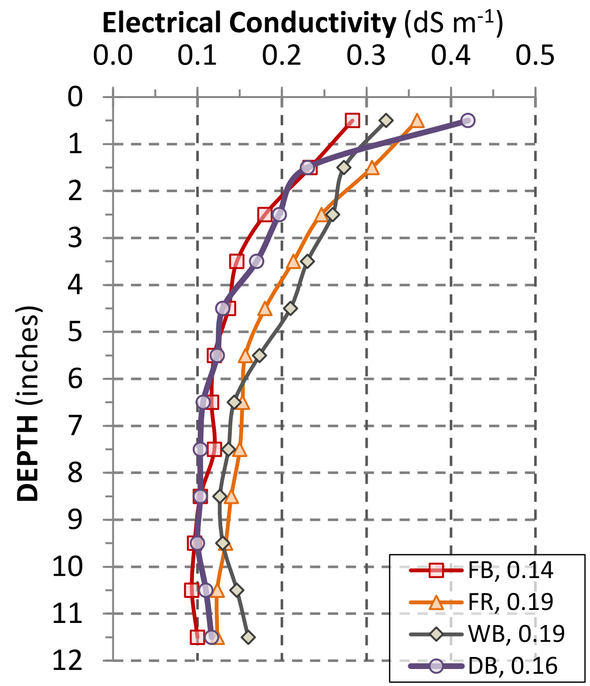
SITE ONE. WEST ASPECT – WALLA WALLA



SITE TWO. EAST ASPECT – WALLA WALLA

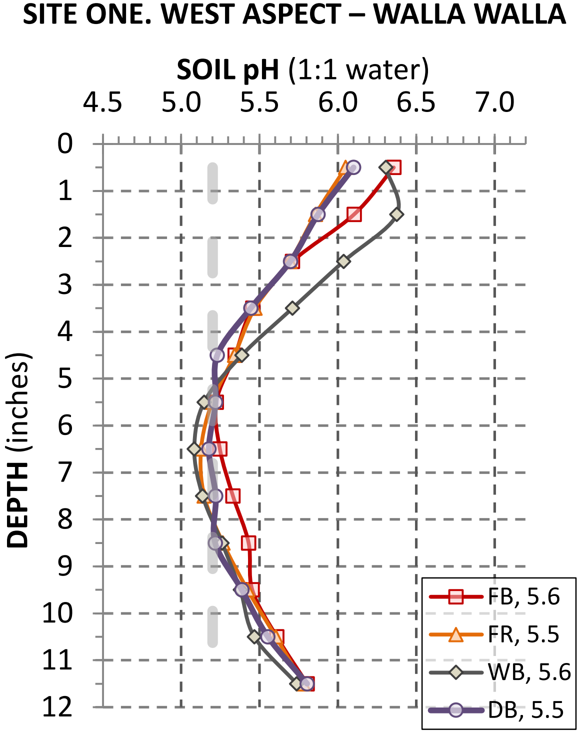


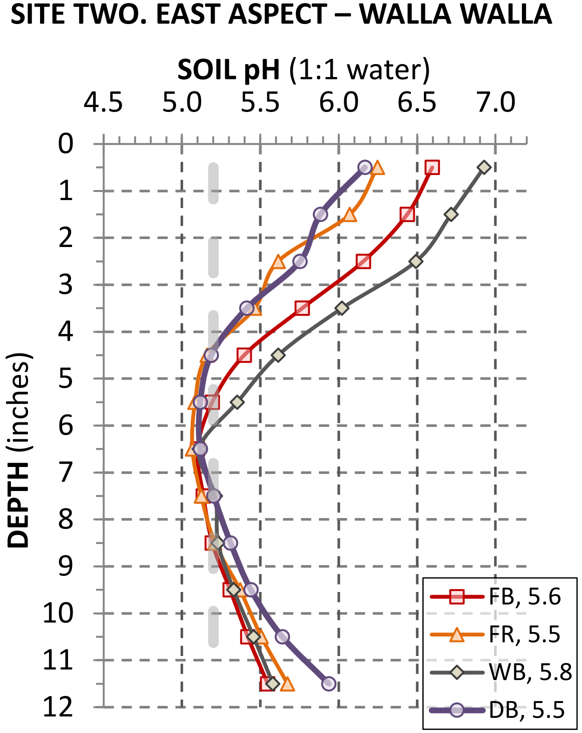
SITE THREE. WEST ASPECT – COOK

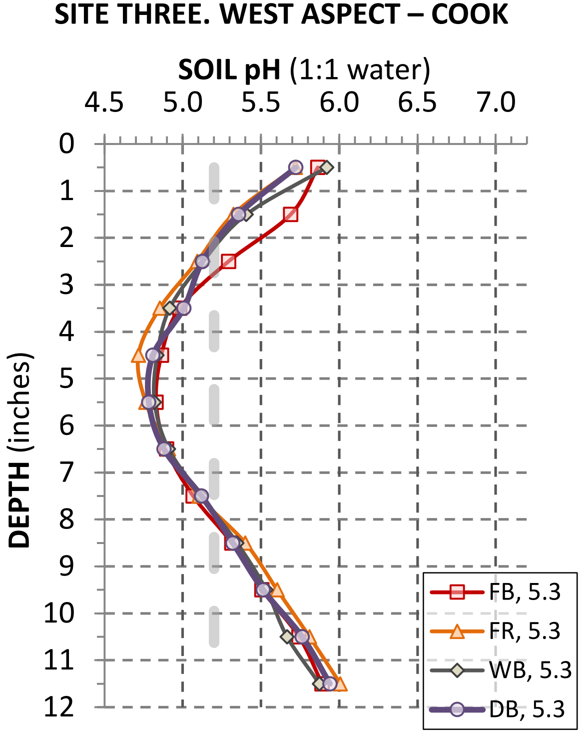


Site Descriptions. Soil pH

ΔpH is high under fall burn in soil with lower buffering capacity







Objective 1. Edaphic effects

Assumptions: Soil cover alters soil warming, evaporative water loss, evapotranspiration, and soil water storage

1. Monitored soil and canopy temperature from early heading through maturity
   – soil temperature under no-till treatment consistently lower the under fall burn (minor exceptions)
   – magnitude of diurnal canopy temperature change over no-till consistently larger than over fall-burn

Temperature logging station

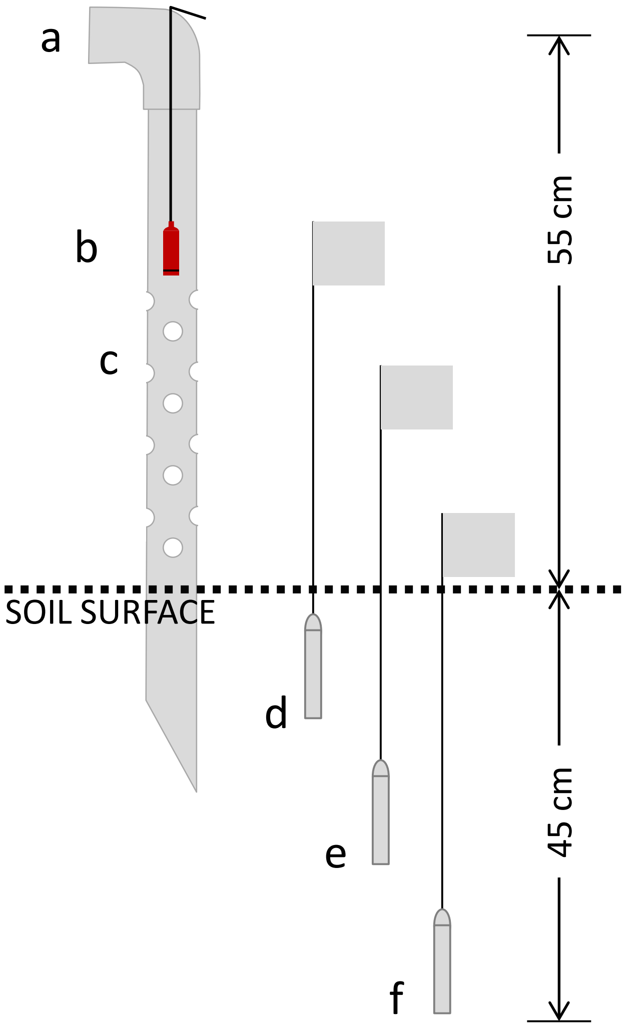
Crop canopy/near-surface and soil temperatures at three depths.

(a) rigid 5-cm × 75-cm white PVC tube capped with a 90° PVC elbow;

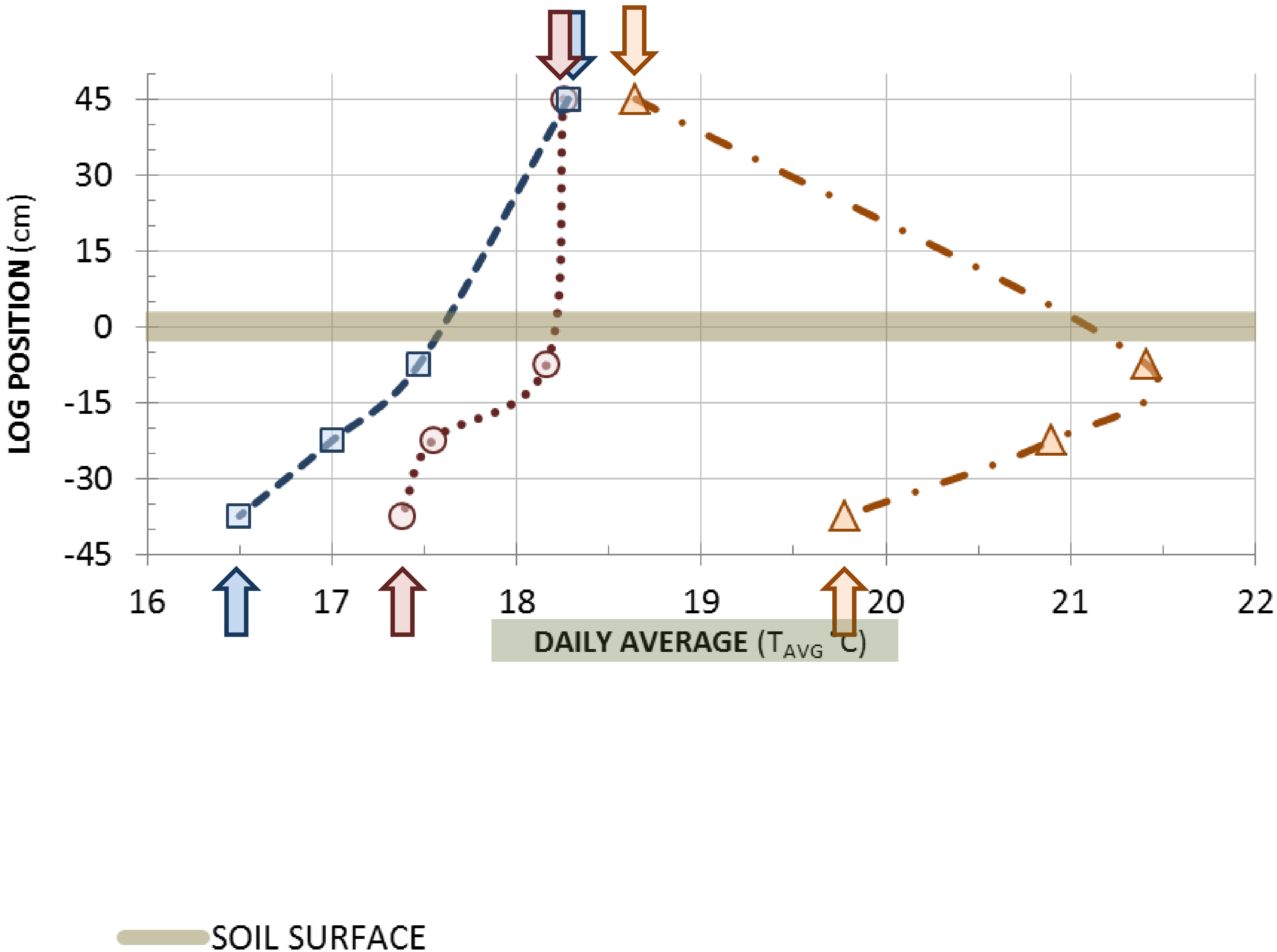
(b) Labjack Digit-TL temperature data logger sealed in red aluminum capsule and dangled with wire inside of PVC tube;

(c) sixteen 1.9-cm holes to facilitate free/convective air-flow through PVC tube;

(d, e, f) Lascar EL-USB-1 temperature data loggers in brushed aluminum capsules buried vertically at resting depths of 15 cm (d), 30 cm (e), and 45 cm (f).



Crop residue layer serves as insulation



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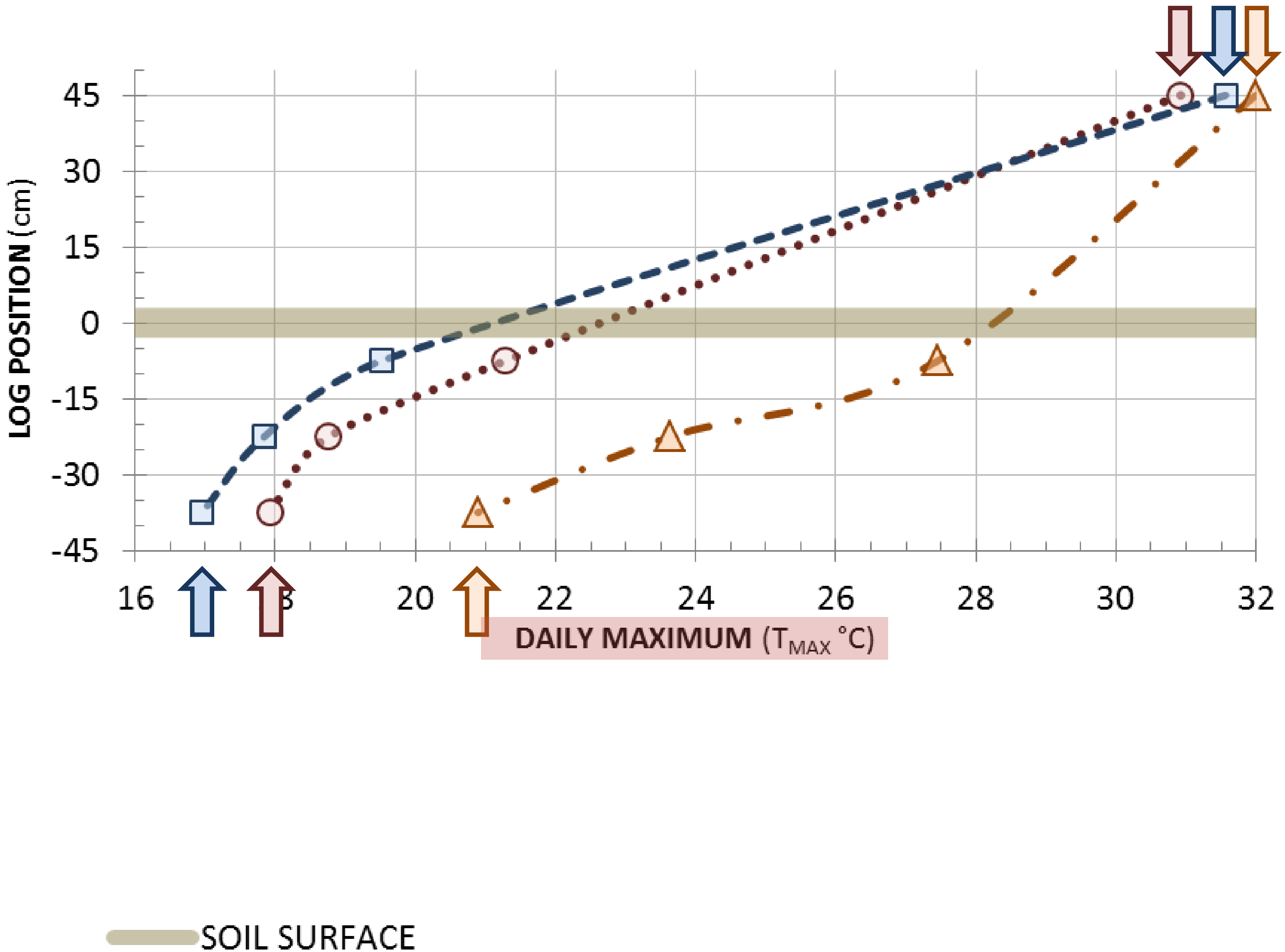

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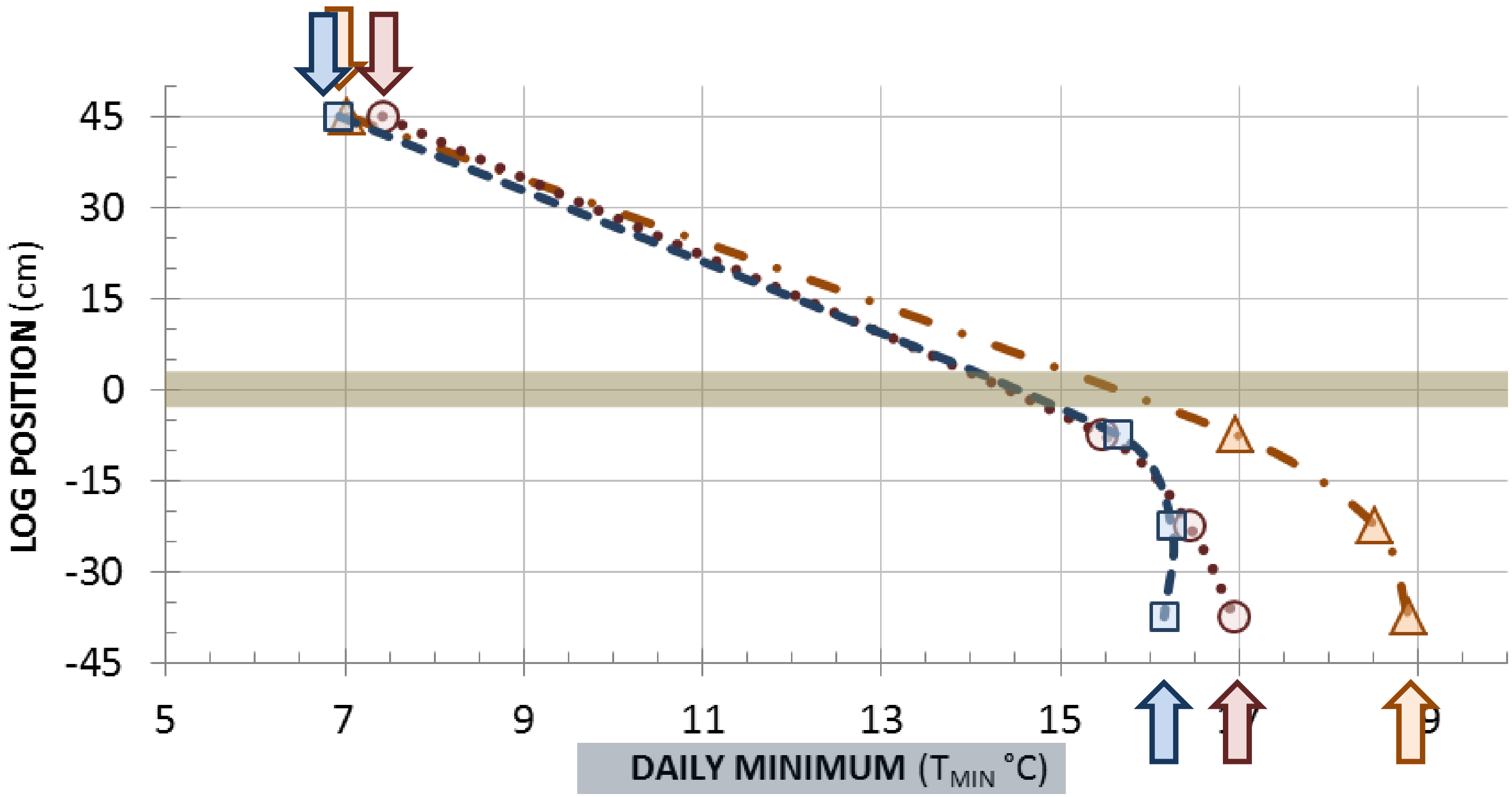
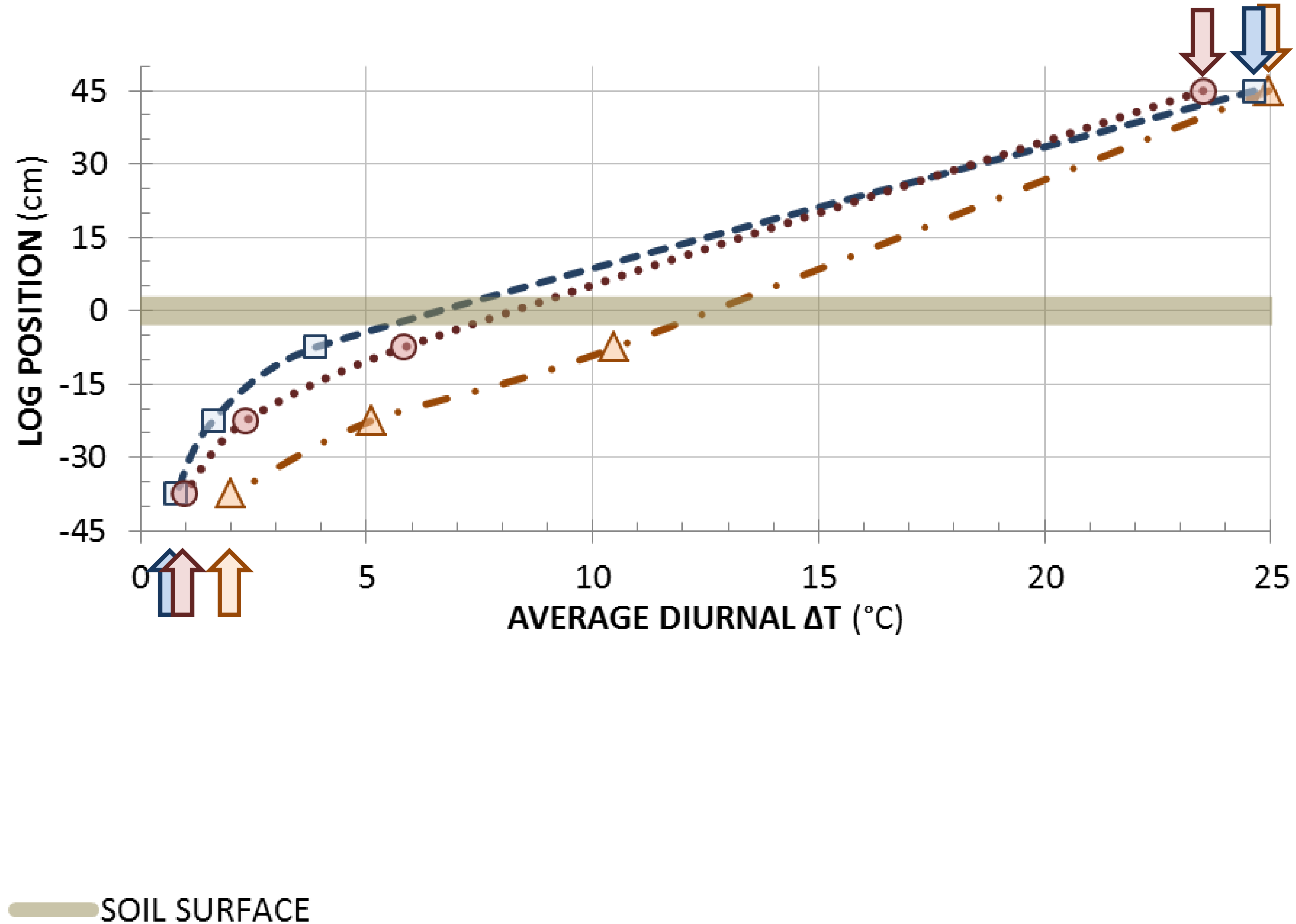


SOIL SURFACE

Crop residue layer serves as insulation

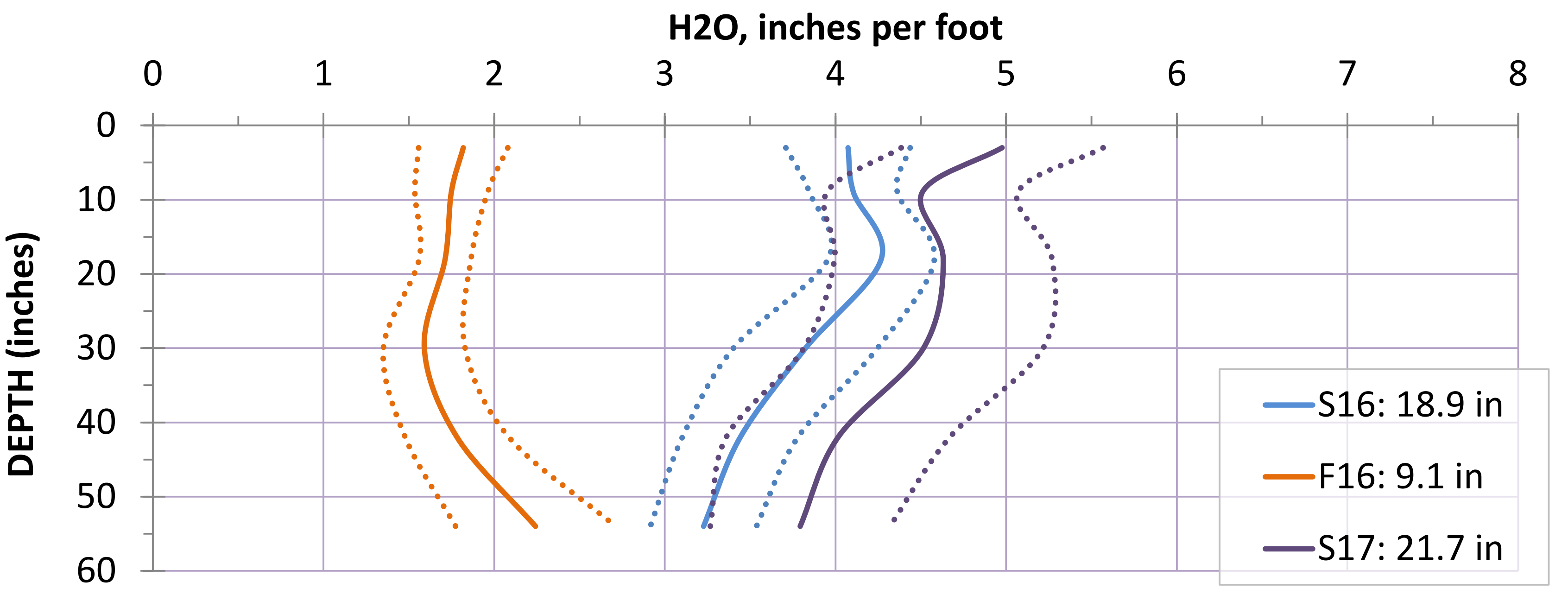


Observations. Temperature on Carbon and Nitrogen in Grain and Straw

- Carbon concentrations in grain and straw are slightly, but consistently lower under no-till versus fall burn
  - *Assumption*.
    - Lower soil temperatures reduces root respiration rates, leading to more efficient carbon utilization which affects grain yield and quality (higher starch content)
    - Average daily minimum temperatures under no-till consistently lower under no-till treatment
- Nitrogen concentrations in grain (protein as well) and straw in sites one and two lower under no-till. Recall that site three had higher soil organic matter content. Concentrations decrease with increasing soil temperature
  - *Assumption*.
    - Nitrogen cycling affected by presence of higher carbon load of no-till. Increased microbial activity diverted N from N pool (lower grain protein content).

Soil Moisture

- *Observations*. Minor difference in soil water status across treatments. Overall averages presented …



Stored Water

Inches of water per five feet of soil, 2016/2017.

Student’s t-test: different letters among treatments by site (rows) are significantly different (P<0.05); Different letter among sites (AVG column) are significantly different (P<0.05).

	TREATMENTS				AVG
	FB	FR	WB	DB	
SITE 1	9.4a	9.9a	10a	9.8a	9.8c
SITE 2	12.7a	12.3a	13.1a	13a	12.8b
SITE 3	15a	15.4a	14.5a	14.3a	14.8a
AVERAGE	12.4a	12.6a	12.3a	12.4a	12.4

Note aspect effect: site 1 (west) versus site 2 (east)

Evapotranspiration

- Table 1. Evapotranspiration estimates (ET), inches of water per five feet.
  - Student's t-test: different letters among treatments by site (rows) are significantly different ($P<0.05$); Different letter among sites (AVG column) are significantly different ($P<0.05$).

	TREATMENTS				AVG
	FB	FR	WB	DB	
SITE 1	25.1a	25.3a	25.6a	25.3a	25.3b
SITE 2	25a	26.3a	25.7a	26a	25.7b
SITE 3	30.1a	30.9a	30.1a	29.4a	30.1a
AVG	26.7a	27.5a	27a	26.8a	27

Water Use Efficiency

		TREATMENTS				AVG
		FB	FR	WB	DB	
GRAIN (bu/inch H_2O)	SITE 1	4.31a	3.74b	4.19a	3.44b	3.92a
	SITE 2	3.58a	3.85a	3.35a	3.55a	3.58b
	SITE 3	1.17b	1.2b	1.87a	1.14b	1.35c
	AVG	3.02ab	2.93b	3.14a	2.71c	2.95
STRAW (ton/inch H_2O)	SITE 1	0.15a	0.14a	0.15a	0.15a	0.15b
	SITE 2	0.17a	0.15a	0.17a	0.17a	0.16a
	SITE 3	0.09a	0.08a	0.08a	0.08a	0.08c
	AVG	0.14a	0.12b	0.13a	0.13a	0.13
BIOMASS (ton/inch H_2O)	SITE 1	0.28a	0.25a	0.28a	0.26a	0.27a
	SITE 2	0.28a	0.27a	0.27a	0.28a	0.27a
	SITE 3	0.12ab	0.11ab	0.14a	0.11b	0.12b
	AVG	0.23a	0.21b	0.23a	0.21ab	0.22

Objective 2. Nutrient status and removal

- Crop residue management effects implemented for this project include:
  - (i) rapid full burn of crop residues post-harvest (FB);
  - (ii) fully retained crop residues as soil cover (FR);
  - (iii) slow and relatively high temperature burn of windrowed post-harvest crop residues (WB); and
  - (iv) straw removal by simulated direct bale (DB).
  - Nutrient testing was performed on soil, plant tissue (grain and straw), ash and charred stubble from the burn treatments, and standing stubble under the unburned residue treatments.

Nutrient testing for soil and biomass samples

SOIL SAMPLES			SOIL AND BIOMASS SAMPLES	
Indicator Tests	Extractables	Metals, Extractables	Totals	Metals, Totals
Density, g/cm3	NH4N, ppm	Al (KCl), ppm	Carbon, %	Al, mg kg-1
Ec(1:1), dS/m	NO3N, ppm	Al (DTPA), ppm	Nitrogen, %	As, mg kg-1
OM, %	Bray P1(1:10), ppm		P, mg kg-1	Ba, mg kg-1
Total Bases, meq/100g	Bicarb P, ppm		K, mg kg-1	Cd, mg kg-1
CEC, meq/100g	SO4S, ppm		S, mg kg-1	Cr, mg kg-1
Estimated CEC, meq/100g	Cl, ppm		Ca, mg kg-1	Ni, mg kg-1
pH (1:1),	B, ppm		Mg, mg kg-1	Pb, mg kg-1
Buffer pH (A-E),	Zn, ppm		Na, mg kg-1	Sr, mg kg-1
	Mn, ppm		Zn, mg kg-1	
	Cu, ppm		Mn, mg kg-1	
	Fe, ppm		Cu, mg kg-1	
	Bicarb K, ppm		Fe, mg kg-1	
	Na (KCl), ppm		B, mg kg-1	
	Ca (KCl), ppm		Mo, mg kg-1	
	Mg (KCl), ppm		Co, mg kg-1	
			Se, mg kg-1	

Objective 2. grain and straw yields, soil cover (residue) and removal by burning and simulated direct bale

Student's t-test: different letters among treatments grouped by year and treatment (rows) are significantly different (P<0.05).

AVERAGES BY YEAR	2015				2016			
	FB	FR	WB	DB	FB	FR	WB	DB
GRAIN YIELDS, bu/A	106b	105b	107b	113a	78a	77ab	83a	71b
STANDING STRAW, Lb/A	9376ab	9077b	9400ab	9495a	7082a	6568a	7029a	7049a
TREATMENT PARAMETERS								
RESIDUE COVER, Lb/A	3514bc	9077a	4052b	3021c	663c	6568a	3071b	2770b
ASH, Lb/A	2840a	.	1561b	.	340b	.	536b	.
REMOVED, Lb/A	5863ab	0c	5347b	6474a	6418a	0c	3959b	4279b
STUBBLE, Lb/A	674d	9077a	2492c	3021b	324c	6568a	2535b	2770b

OBJECTIVE TWO. Partial enterprise budget

Prices for nutrient replacement presented in table are adapted from the publication "Idaho Crop Input Price Summary for 2015" prepared by Patterson, et. al., University of Idaho.

- Value of soft white winter wheat grain and straw were assumed to be $5.00 per bushel (corrected to 12% moisture) and $60 per ton of baled straw.

Nutrient	Replacement Value *($/Lb of nutrient)*	Replacement Fertilizer Source	Replacement Fertilizer Guaranteed Analysis
Nitrogen	$ 0.59	Anhydrous Ammonia	82-0-0
Phosphorus (P2O5)	$ 0.71	Ammonium Polyphosphate	10-34-0
Potassium (K2O)	$ 0.31	Muriate of Potash (KCl)	0-0-60
Sulfur (S)	$ 0.28	Dry Sulfur (elemental)	0-0-0-90S
Zinc (Zn)	$ 3.45	Zinc Sulfate	0-0-0-17S-36Zn
Boron (B)	$ 10	Boron	0-0-0-14B
Copper (Cu)	$ 14	Copper Sulfate	0-0-0-25Cu
Iron (Fe)	$ 1.50	Iron Sulfate	0-0-0-50Fe
Manganese (Mn)	$ 4.65	Manganese Sulfate	0-0-0-32Mn
Magnesium (Mg)	$ 0.038	Magnesium Sulfate	0-0-0-12.9S-9.8Mg
Calcium (Ca)	$ 0.034	Calcium Sulfate (gypsum)	0-0-0-16S-21Ca
Chloride (Cl^-)	$ 0.31	Potassium Chloride	0-0-60-40Cl

OBJECTIVE TWO. Partial enterprise budget

Partial enterprise budget assumed constant grain and biomass yield, plus relative residue and removal rates by treatment. Grain and straw yields are based on a harvest index of 0.40 and assumed equal for all treatments.

Values are extrapolated from findings with this study, and deviate only slightly from findings from our previous burn studies.

Treatments	Lost/Removed (Lb/A)	Grain (Lb/A)	Straw (Lb/A)	Stubble (Lb/A)	Ash (Lb/A)
Full Burn (FB)	6480	6000	9000	900	1620
Fully Retained Residues (FR)	0	6000	9000	9000	0
Windrow Burn (WB)	1620	6000	9000	3780	3600
Direct Bale (DB)	5625	6000	9000	3375	0

OBJECTIVE TWO. Partial enterprise budget

OVERALL AVERAGES	TREATMENTS ($/A)			
	FB	FR	WB	DB
NET RETURN BY TRT ($/A)	448b	500c	488a	626d
Value of bale ($/A)				
VALUE OF BALE REMOVED ($/A)	0	0	0	169
NPKS LOST WITH SMOKE OR REMOVED IN BALES ($/A)				
TOTAL LOST/REMOVED	52d	0c	12b	42a
N ($0.59/Lb-N)	13.16d	0c	2.99b	10.45d
P2O5 ($0.71/lb-P2O5)	1.31d	0c	0.33b	1.17a
K2O ($0.31/Ln-K2O)	36.59d	0c	8.58b	29.59a
S ($0.28/Lb-S)	1.39d	0c	0.32b	1.11

Where values of nutrients ($/Lb) are: N = $0.59; P2O5 = $0.71; K2O = $0.31; S = $0.28

OBJECTIVE TWO. Nutrient Status

Average nutrient Loss by treatment (Lb/A).

1. Burn increased removal rates of nitrogen and sulfur.
2. Carbon and potassium removal rates are positively correlated with straw yield.
3. Burn (ash) alters the availability of most secondary and micro nutrients. Note however that a comprehensive analysis of the data combined with critical review is needed to confirm.

NUTRIENTS	2015				2016			
	FB	FR	WB	DB	FB	FR	WB	DB
Carbon (C)	3150a	0b	3155a	2919a	2917a	0c	2063b	1919b
C:N Ratio	449a	0b	245ab	348a	129ab	0b	318a	326a
Potassium (K2O)	91b	0c	102b	117a	98a	0c	62b	65b
Nitrogen (N)	10.5a	0b	11.2a	10.3a	23.3a	0c	8.2b	7.9b
Calcium (Ca)	0c	0c	2.2b	3.8a	11.1a	0c	4.2b	5.5b
Phosphorus (P2O5)	0b	0b	0.18b	0.72a	1.36a	0c	0.39bc	0.65b
Magnesium (Mg)	0c	0c	0.8b	2.1a	3.5a	0d	1.4c	2.2b
Sulfur (S)	4.17a	0b	3.74a	4.26a	5.7a	0c	3.11b	3.1b
Iron (Fe)	0a	0a	0a	0a	0a	0a	0a	0a
Manganese (Mn)	0b	0b	0.05b	0.13a	0.37a	0c	0.17b	0.27a
Sodium (Na)	0c	0c	0.07b	0.23a	0.25a	0b	0.2a	0.31a
Zinc (Zn)	0b	0b	0.002b	0.013a	0.017a	0b	0.004b	0.012a
Copper (Cu)	0.001b	0b	0.001b	0.018a	0.003ab	0c	0.001bc	0.004a
Boron (B)	0.039a	0b	0.042a	0.041a	0.019a	0c	0.011b	0.011b
Selenium (Se)	0.0011b	0b	0.0034a	0.0046a	0.0047a	0b	0.0045a	0.0062a
Nickel (Ni)	0b	0b	0b	0.0006a	0a	0a	0a	0.0009a
Molybdenum (Mo)	0.005b	0c	0.005b	0.007a	0.001a	0c	0b	0b

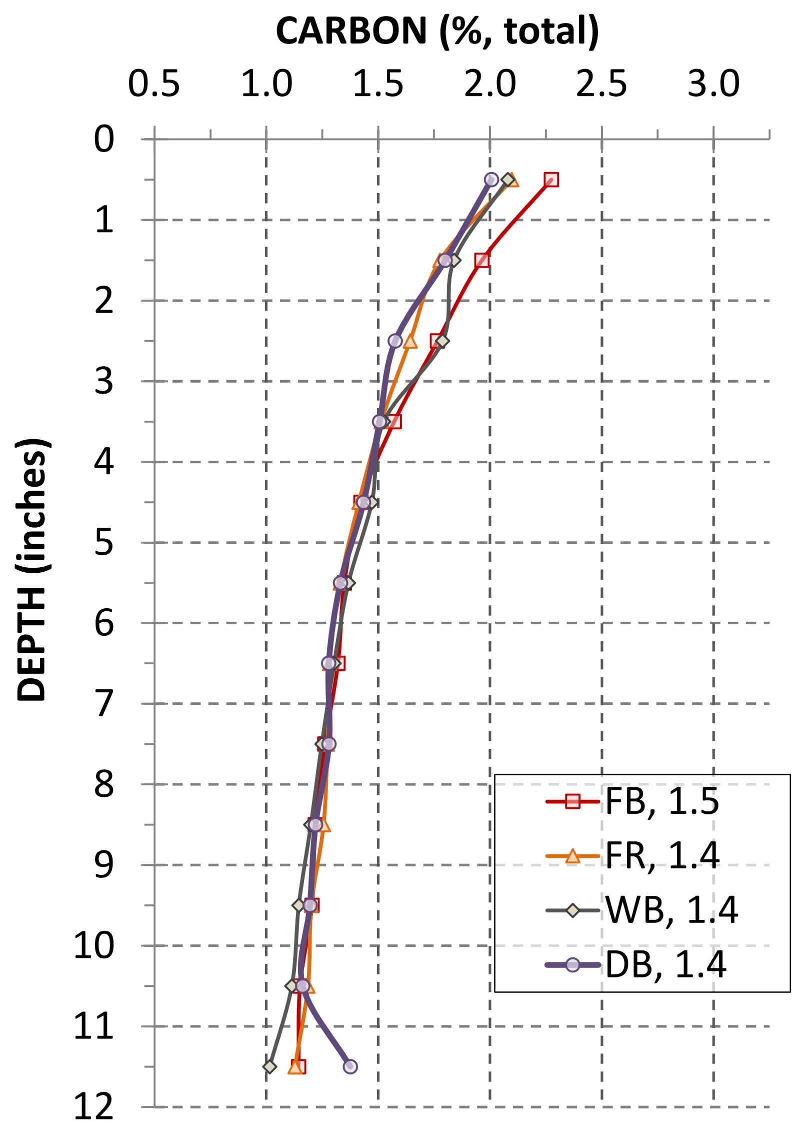
Nutrient Status. Carbon

Observations. No statistical differences across treatments by depth. Significant differences observed across biomass partitions

Biomass Partitions

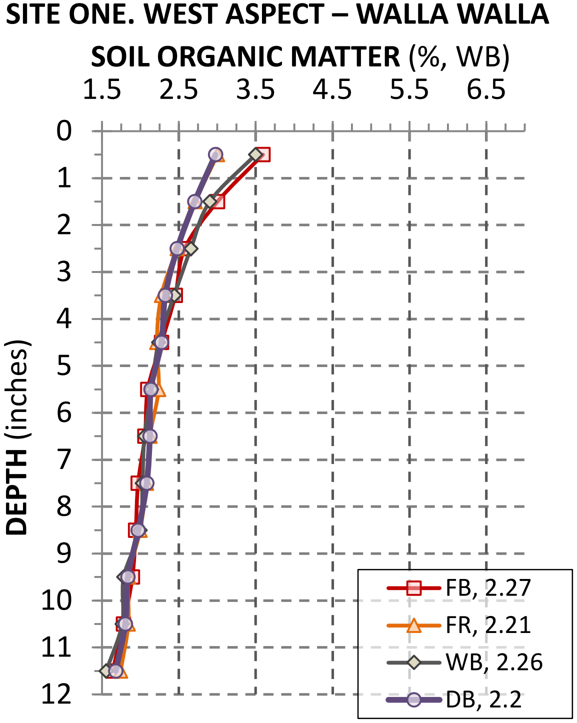
SAMPLE	FB	FR	WB	DB
GRAIN	41.84 a	41.85 a	41.71 a	41.82 a
STRAW	43.01 a	43.23 a	43.39 a	43.14 a
COVER	25.23 b	40.95 a	18.66 c	40.92 a
ASH	21.61 a	*NA*	9.84 b	*NA*
FATE OF BIOMASS CARBON, C, ratio				
GRAIN	0.40 a	0.41 a	0.40 a	0.39 a
COVER	0.16 c	0.59 a	0.25 b	0.20 b
B & B*	0.49 a	0.00 d	0.36 c	0.38 b

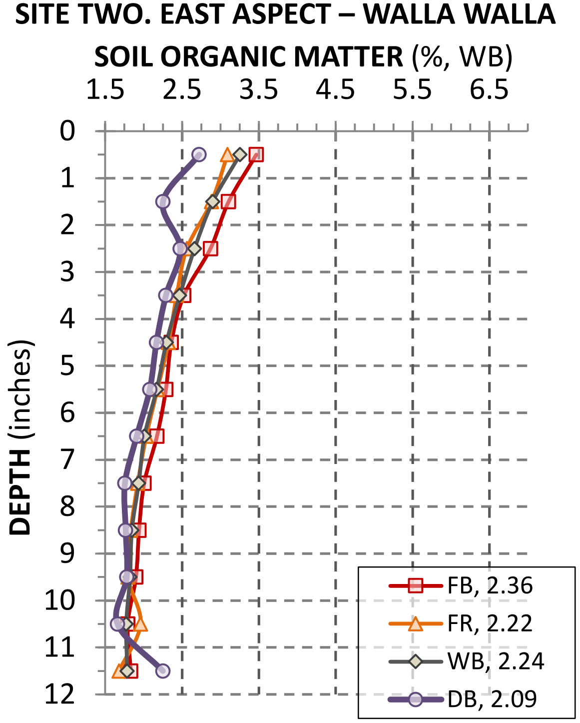
** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*

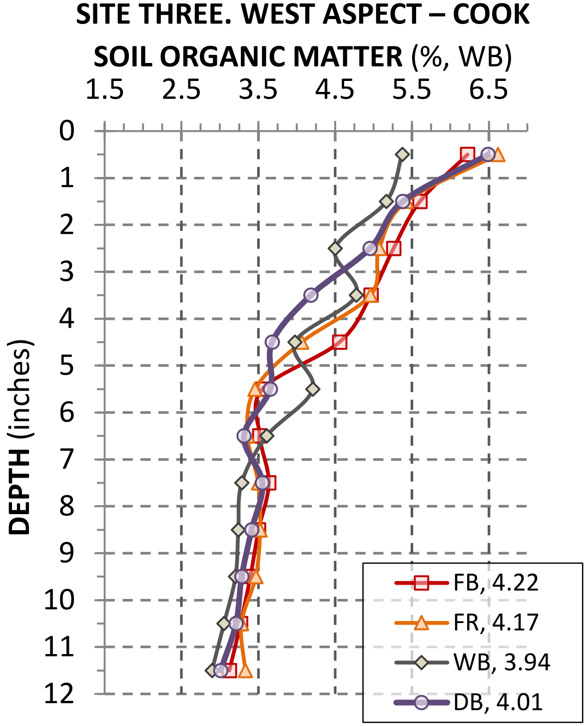


Recall Site Descriptions.
Soil Organic Matter

- Soil with high organic matter content has higher pH and nutrient buffering capacity
- Clay content affects nutrient buffering capacity







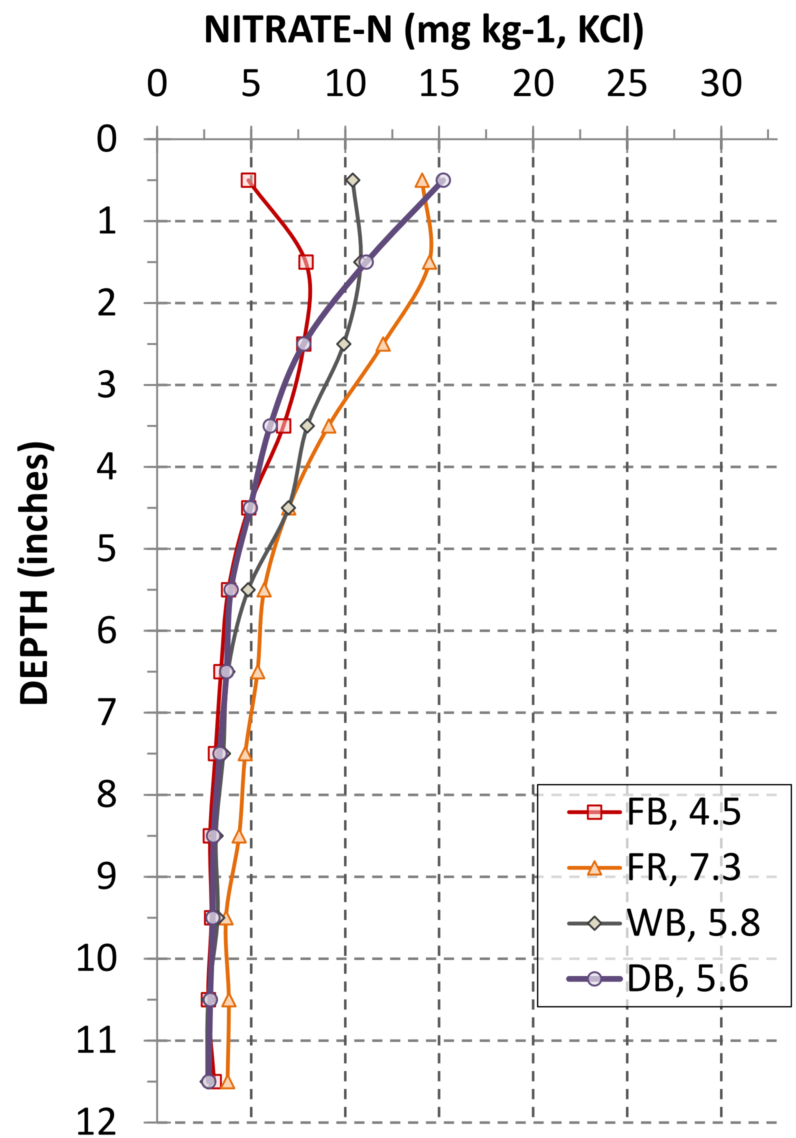
Nutrient Status. Nitrate Nitrogen

Observations. Statistical differences across treatments throughout profile (NO3-N). Significant differences observed across treatments among biomass partitions (N).

Biomass Partitions ([N], %)

SAMPLE	FB	FR	WB	DB
GRAIN	1.72 a	1.69 b	1.67 b	1.74 b
STRAW	0.31 a	0.28 b	0.30 b	0.29 ab
COVER	0.53 a	0.42 a	0.41 a	0.53 a
ASH	0.43 a	*NA*	0.29 a	*NA*
FATE OF BIOMASS NITROGEN, N, ratio				
GRAIN	0.81 a	0.81 a	0.80 a	0.79 a
COVER	0.05 a	0.19 b	0.08 b	0.06 ab
B & B*	0.17 a	0.00 c	0.11 b	0.13 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



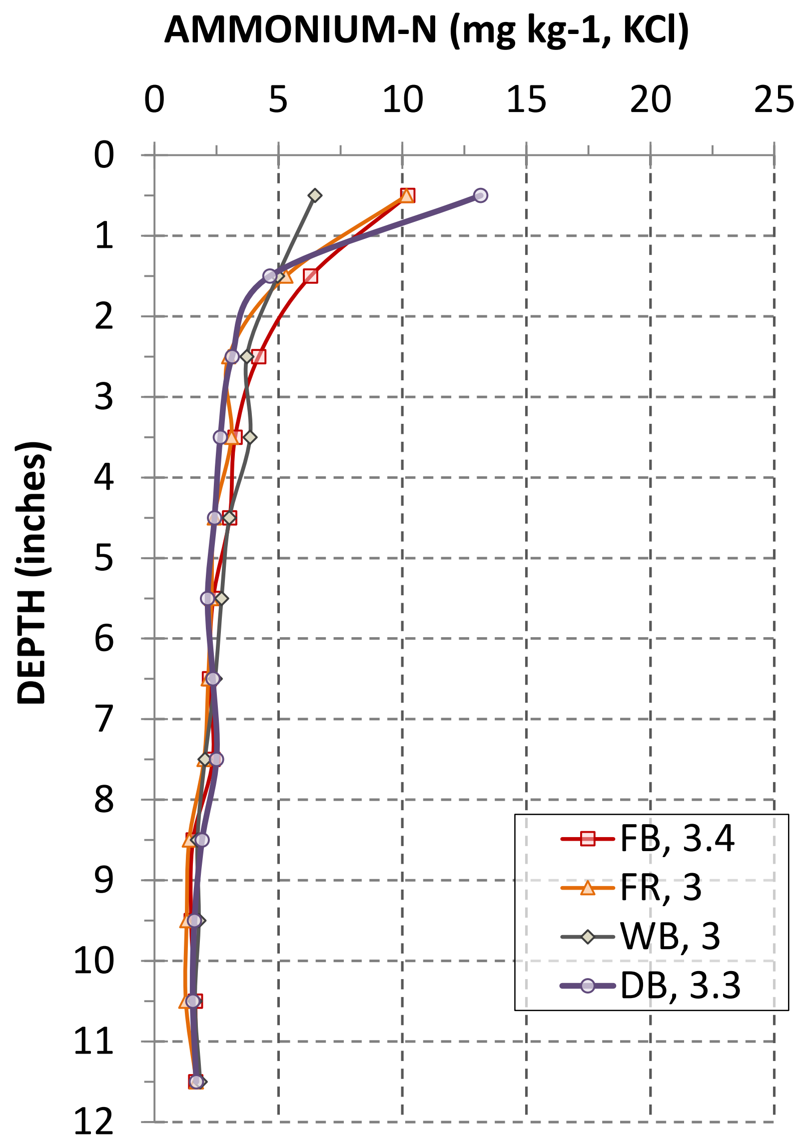
Nutrient Status. Ammonium Nitrogen

Observations. No statistical differences across treatments by depth (NH4-N). Significant differences observed across treatments among biomass partitions (N).

Biomass Partitions ([N], %)

SAMPLE	FB	FR	WB	DB
GRAIN	1.72 a	1.69 b	1.67 b	1.74 b
STRAW	0.31 a	0.28 b	0.30 b	0.29 ab
COVER	0.53 a	0.42 a	0.41 a	0.53 a
ASH	0.43 a	*NA*	0.29 a	*NA*
FATE OF BIOMASS NITROGEN, N, ratio				
GRAIN	0.81 a	0.81 a	0.80 a	0.79 a
COVER	0.05 a	0.19 b	0.08 b	0.06 ab
B & B*	0.17 a	0.00 c	0.11 b	0.13 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



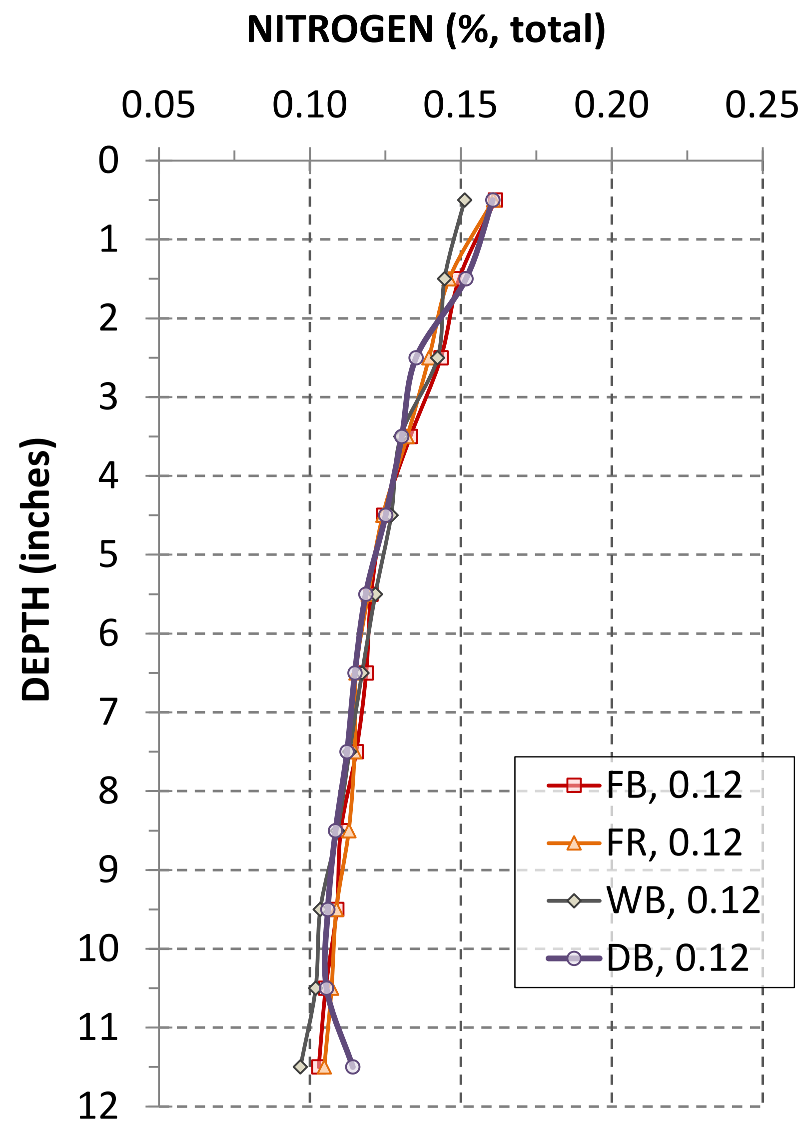
Nutrient Status. Total Nitrogen

Observations. No statistical differences across treatments by depth. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([N], %)

SAMPLE	FB	FR	WB	DB
GRAIN	1.72 a	1.69 b	1.67 b	1.74 b
STRAW	0.31 a	0.28 b	0.30 b	0.29 ab
COVER	0.53 a	0.42 a	0.41 a	0.53 a
ASH	0.43 a	*NA*	0.29 a	*NA*
FATE OF BIOMASS NITROGEN, N, ratio				
GRAIN	0.81 a	0.81 a	0.80 a	0.79 a
COVER	0.05 a	0.19 b	0.08 b	0.06 ab
B & B*	0.17 a	0.00 c	0.11 b	0.13 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



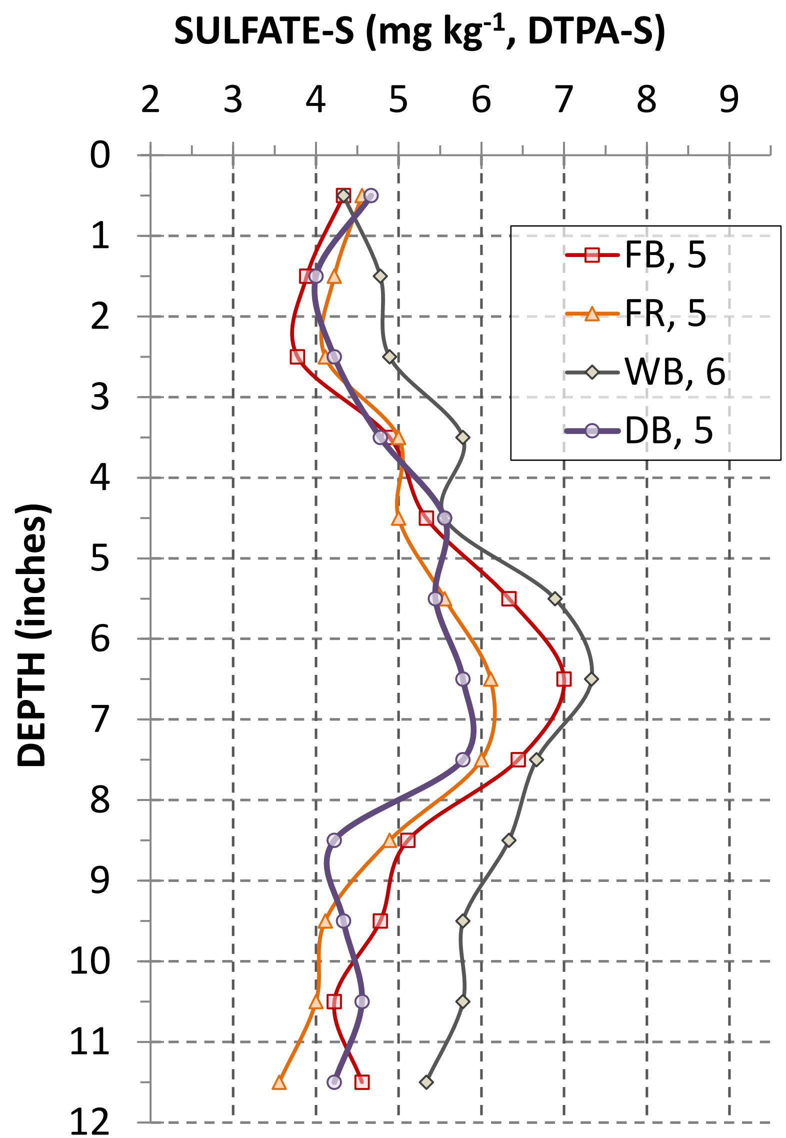
Nutrient Status. Extractable Sulfate

Observations. Significant differences across treatments and soil depths from two to four inches. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([S], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.13 a	0.12 b	0.12 b	0.12 b
STRAW	0.07 a	0.07 b	0.07 b	0.07 b
COVER	0.06 c	0.06 b	0.06 ab	0.07 a
ASH	0.07 b	*NA*	0.24 a	*NA*
FATE OF BIOMASS SULFUR, S, ratio				
GRAIN	0.53 a	0.55 a	0.56 a	0.53 a
COVER	0.12 a	0.45 b	0.18 b	0.15 b
B & B*	0.38 a	0.00 d	0.26 c	0.30 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



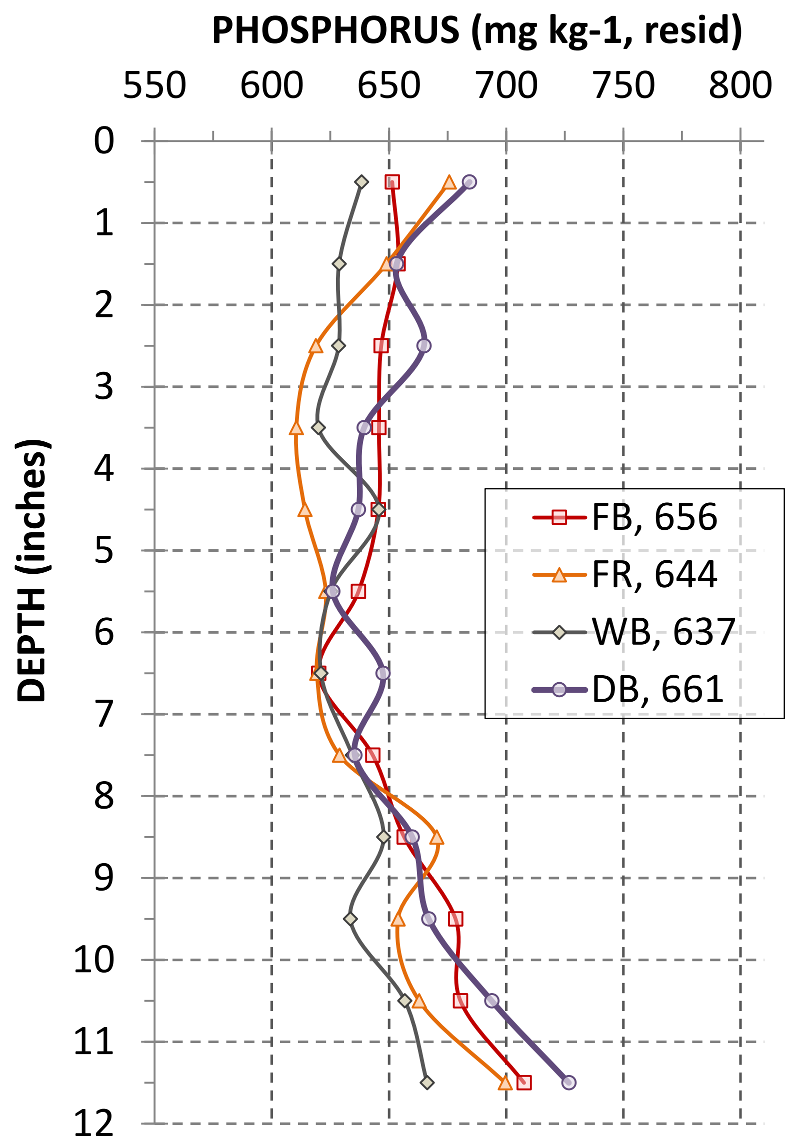
Nutrient Status. Total Phosphorus

Observations. No statistical differences across treatments by depth. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([P], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.29 a	0.29 ab	0.28 b	0.29 a
STRAW	0.02 a	0.03 a	0.03 a	0.03 a
COVER	0.11 b	0.05 d	0.14 a	0.06 c
ASH	0.14 b	*NA*	0.24 a	*NA*
FATE OF BIOMASS PHOSPHORUS, P, ratio				
GRAIN	0.89 a	0.89 a	0.88 a	0.86 a
COVER	0.03 a	0.11 a	0.05 a	0.04 a
B & B*	0.09 a	0.00 c	0.07 b	0.10 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*

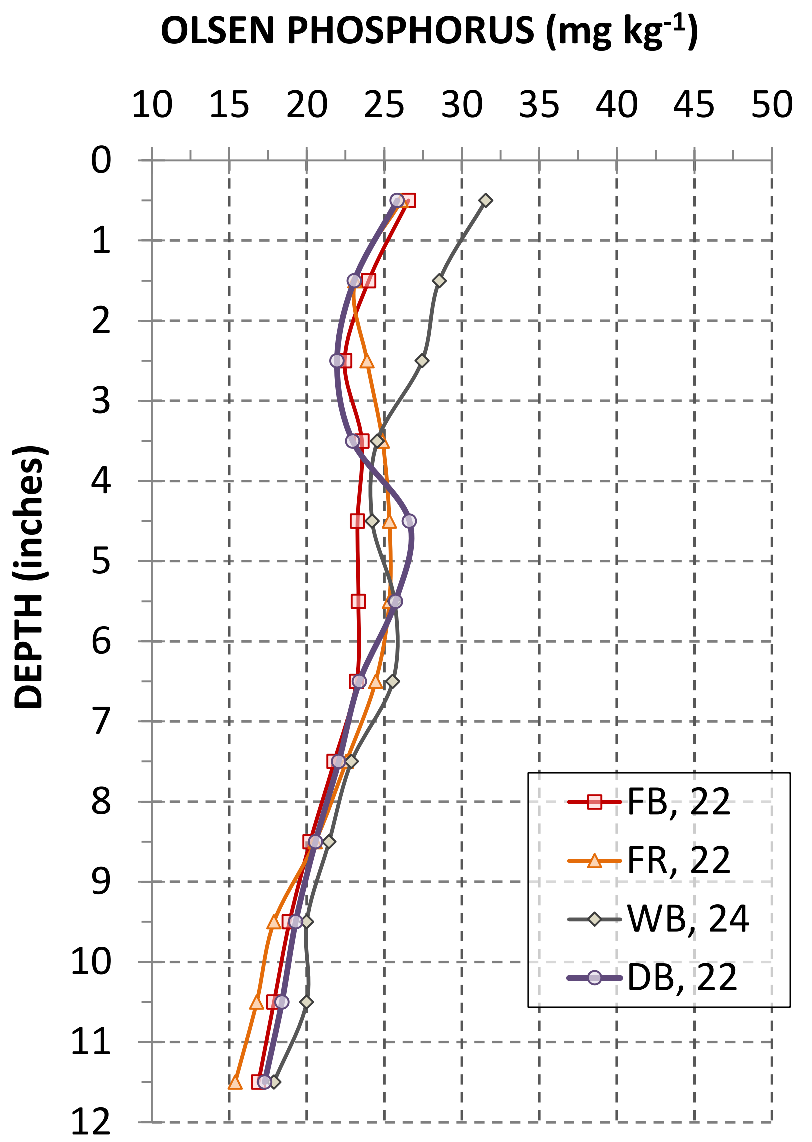


Nutrient Status. Olsen Phosphorus

Observations. Significant differences across treatments at soil depths to three inches (debate ongoing). Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Olsen P], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.29 a	0.29 a	0.28 b	0.29 a
STRAW	0.02 a	0.03 a	0.03 a	0.03 a
COVER	0.11 b	0.05 d	0.14 a	0.06 c
ASH	0.14 b	*NA*	0.24 a	*NA*
FATE OF BIOMASS PHOSPHORUS, P, Lb/ACRE				
GRAIN	17.1 a	17.0 a	17.4 a	15.8 a
COVER	0.6 c	2.0 a	1.0 b	0.7 b
B & B*	1.5 a	0.0 c	1.2 b	1.4 ab



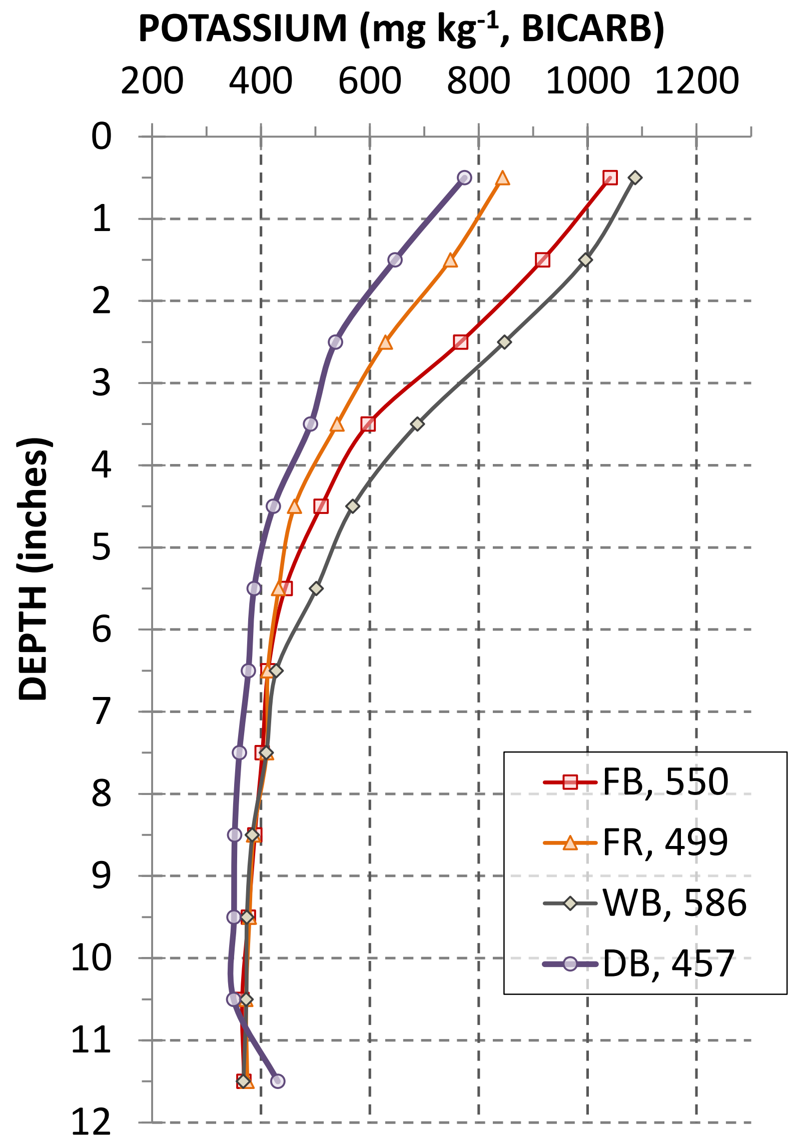
Nutrient Status. Exchangeable Potassium

Observations. Significant differences across treatments at soil depths to ten inches. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([K], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.42 a	0.43 a	0.43 a	0.42 a
STRAW	1.40 a	1.38 ab	1.38 ab	1.39 b
COVER	0.44 c	0.76 bc	1.31 a	0.88 b
ASH	1.83 b	*NA*	4.57 a	*NA*
FATE OF BIOMASS POTASSIUM, K, ratio				
GRAIN	0.16 a	0.17 a	0.17 a	0.17 a
COVER	0.22 a	0.83 ab	0.33 ab	0.27 b
B & B*	0.62 a	0.00 d	0.48 c	0.53 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



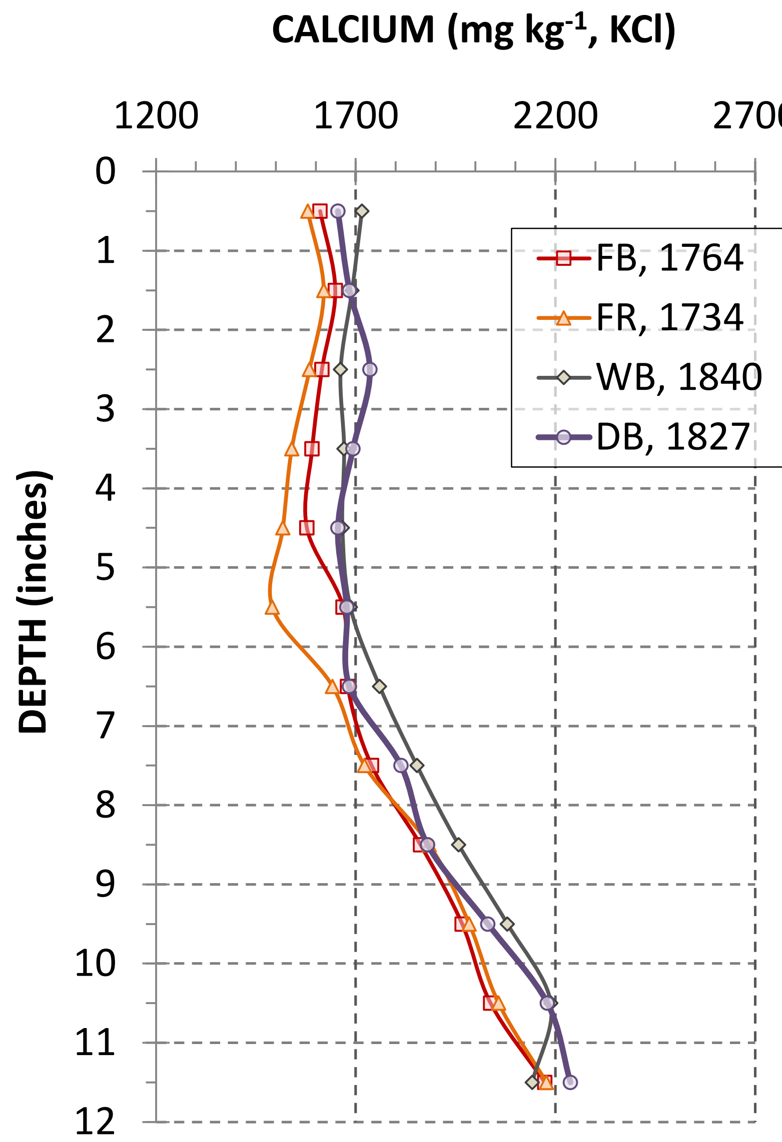
Nutrient Status. Exchangeable Calcium

Observations. Numerical differences across treatments and soil depths. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Ca], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.05 a	0.05 a	0.05 a	0.05 a
STRAW	0.16 a	0.15 b	0.16 b	0.16 ab
COVER	0.27 b	0.26 b	0.40 a	0.29 b
ASH	0.61 b	*NA*	1.16 a	*NA*
FATE OF BIOMASS CALCIUM, Ca, ratio				
GRAIN	0.16 a	0.17 a	0.14 a	0.15 a
COVER	0.21 a	0.83 b	0.33 b	0.28 ab
B & B*	0.60 a	0.00 d	0.46 c	0.54 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



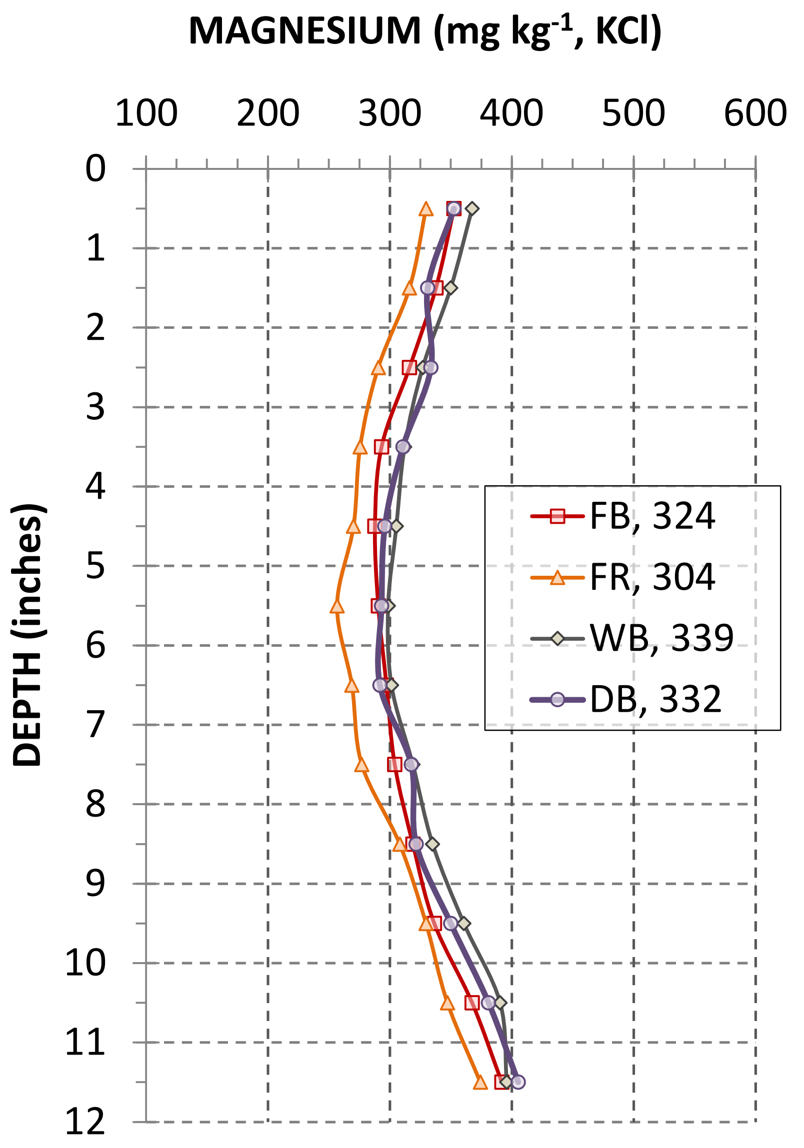
Nutrient Status. Exchangeable Magnesium

Observations. Significant differences across treatments and soil depths from two to four inches. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Mg], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.11 a	0.11 a	0.11 a	0.11 a
STRAW	0.06 a	0.06 b	0.06 ab	0.06 ab
COVER	0.18 b	0.10 c	0.26 a	0.10 c
ASH	0.31 b	*NA*	0.48 a	*NA*
FATE OF BIOMASS MAGNESIUM, Mg ratio				
GRAIN	0.55 a	0.57 a	0.57 a	0.56 a
COVER	0.11 a	0.43 b	0.18 ab	0.15 ab
B & B*	0.34 a	0.00 d	0.26 c	0.30 b

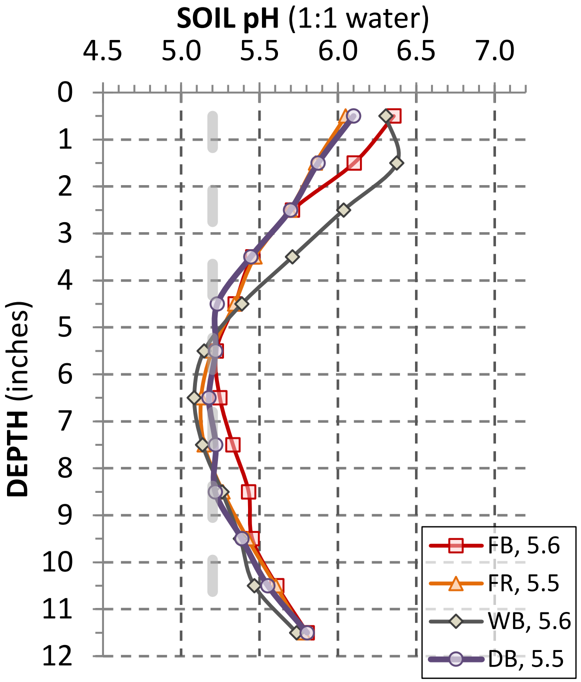
** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



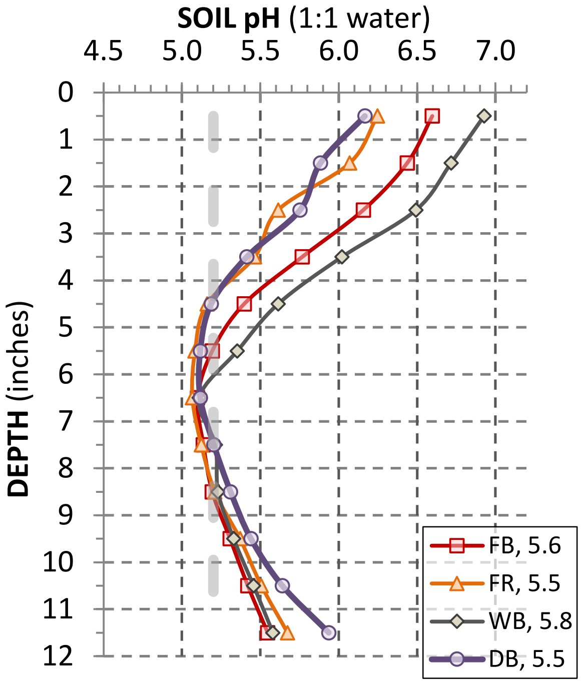
Site Descriptions. Soil pH

ΔpH is high under fall burn in soil with lower buffering capacity

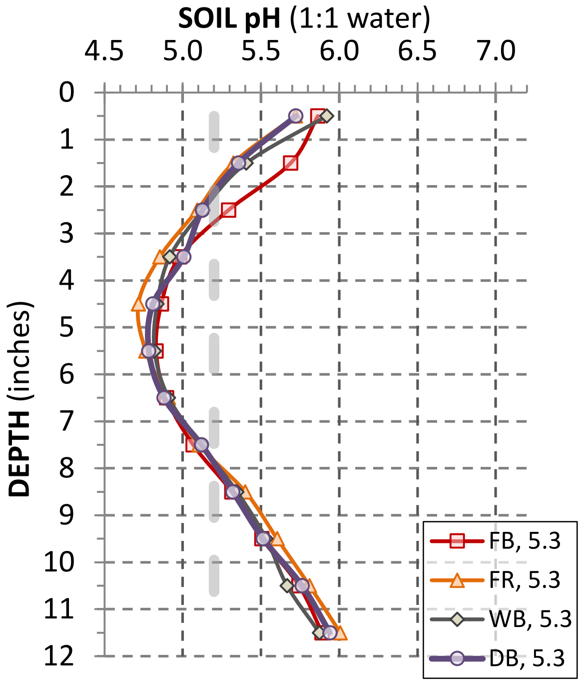
SITE ONE. WEST ASPECT – WALLA WALLA



SITE TWO. EAST ASPECT – WALLA WALLA



SITE THREE. WEST ASPECT – COOK



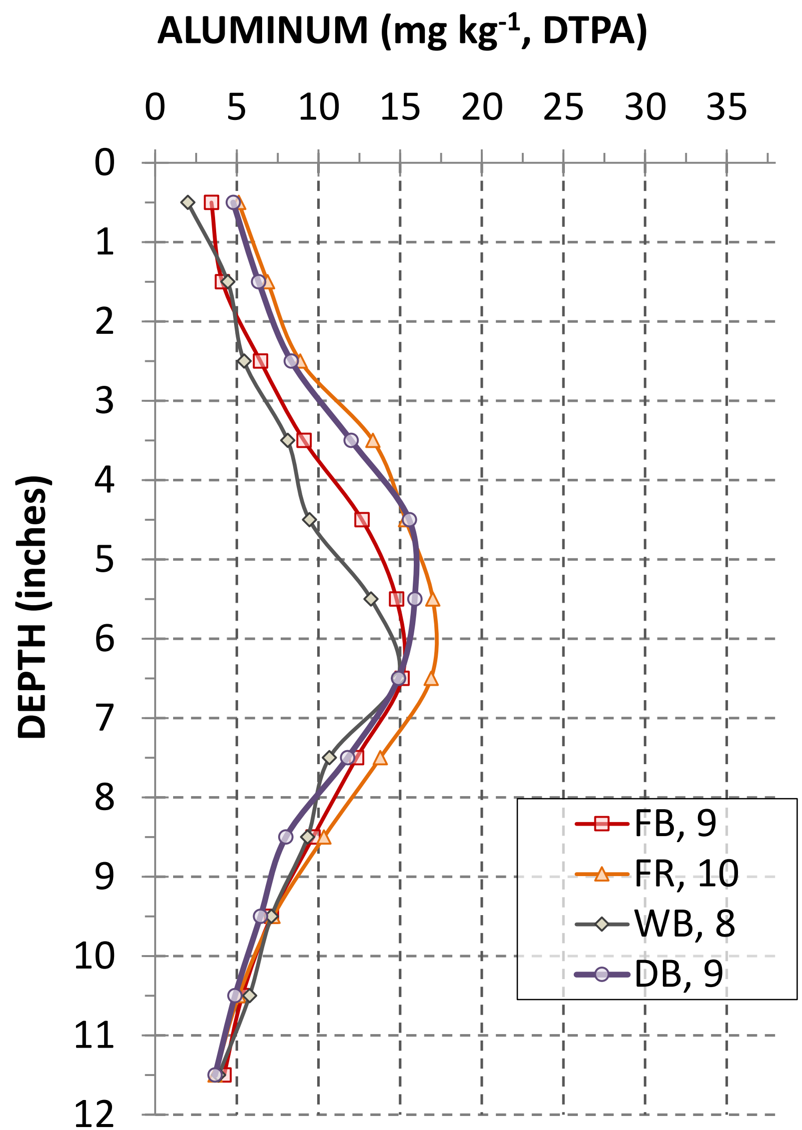
Nutrient Status. Aluminum

Observations. Significant differences across treatments and soil depths from zero to four inch. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Al], %)

SAMPLE	FB	FR	WB	DB
GRAIN	6 a	7 a	5 a	7 a
STRAW	24 a	20 a	20 a	22 a
COVER	4176 b	891 c	7112 a	681 c
ASH	7281 a	*NA*	5837 a	*NA*
FATE OF BIOMASS ALUMINUM, Al, ratio				
GRAIN	0.15 a	0.19 a	0.20 a	0.18 a
COVER	0.23 c	0.81 a	0.32 b	0.26 b
B & B*	0.64 a	0.00 c	0.46 b	0.51 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



Nutrient Status. Manganese

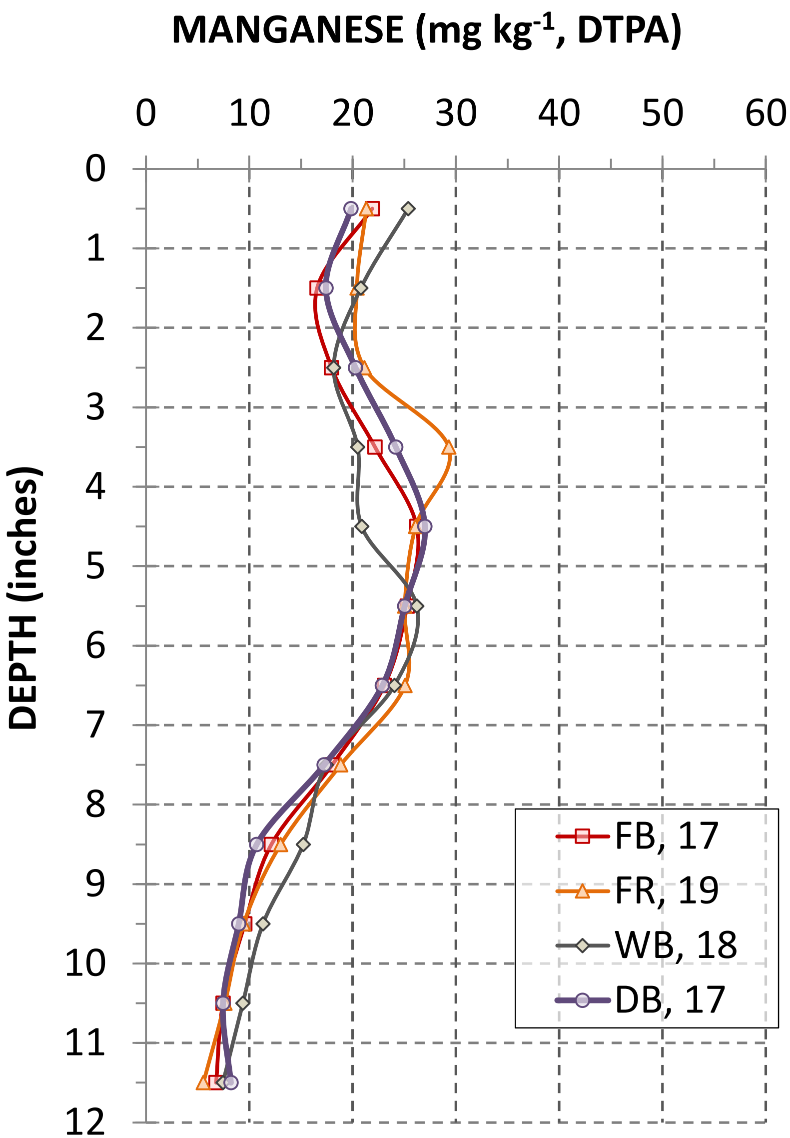
Observations. Numerical differences across treatments and soil depths from zero to one inch. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Mn], %)

SAMPLE	FB	FR	WB	DB
GRAIN	47 a	48 a	47 a	48 a
STRAW	75 a	76 a	70 a	73 a
COVER	249 b	97 c	330 a	117 c
ASH	359 b	*NA*	566 a	*NA*

FATE OF BIOMASS MANGANESE, Mn, ratio				
GRAIN	0.34 a	0.35 a	0.32 a	0.29 a
COVER	0.14 c	0.65 a	0.25 b	0.21 b
B & B*	0.53 a	0.00 d	0.32 c	0.40 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



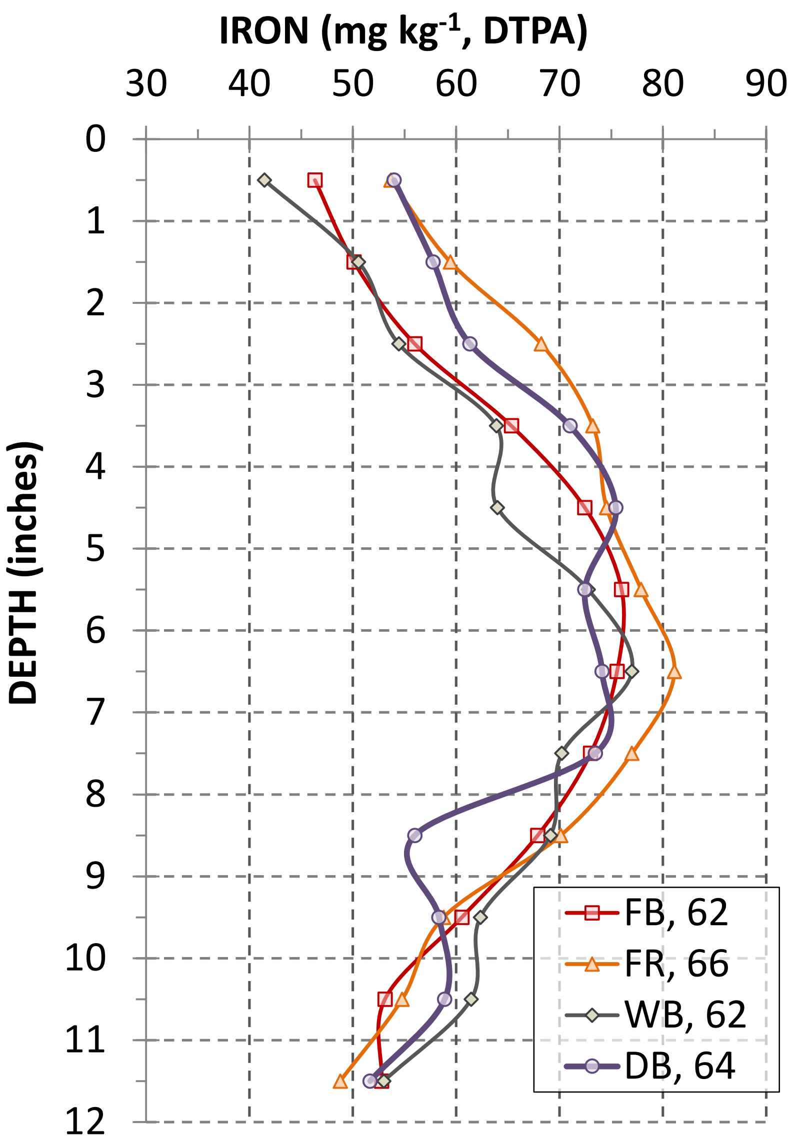
Nutrient Status. Iron

Observations. Significant differences across treatments and soil depths from zero to one inch. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Fe], %)

SAMPLE	FB	FR	WB	DB
GRAIN	37 a	35 a	33 a	38 a
STRAW	48 a	45 b	47 ab	51 a
COVER	6940 a	1031 b	8610 a	881 b
ASH	8809 a	*NA*	7068 a	*NA*
FATE OF BIOMASS IRON, Fe, ratio				
GRAIN	0.32 b	0.36 a	0.34 ab	0.35 ab
COVER	0.17 c	0.64 a	0.25 b	0.23 b
B & B*	0.50 a	0.00 d	0.36 c	0.43 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



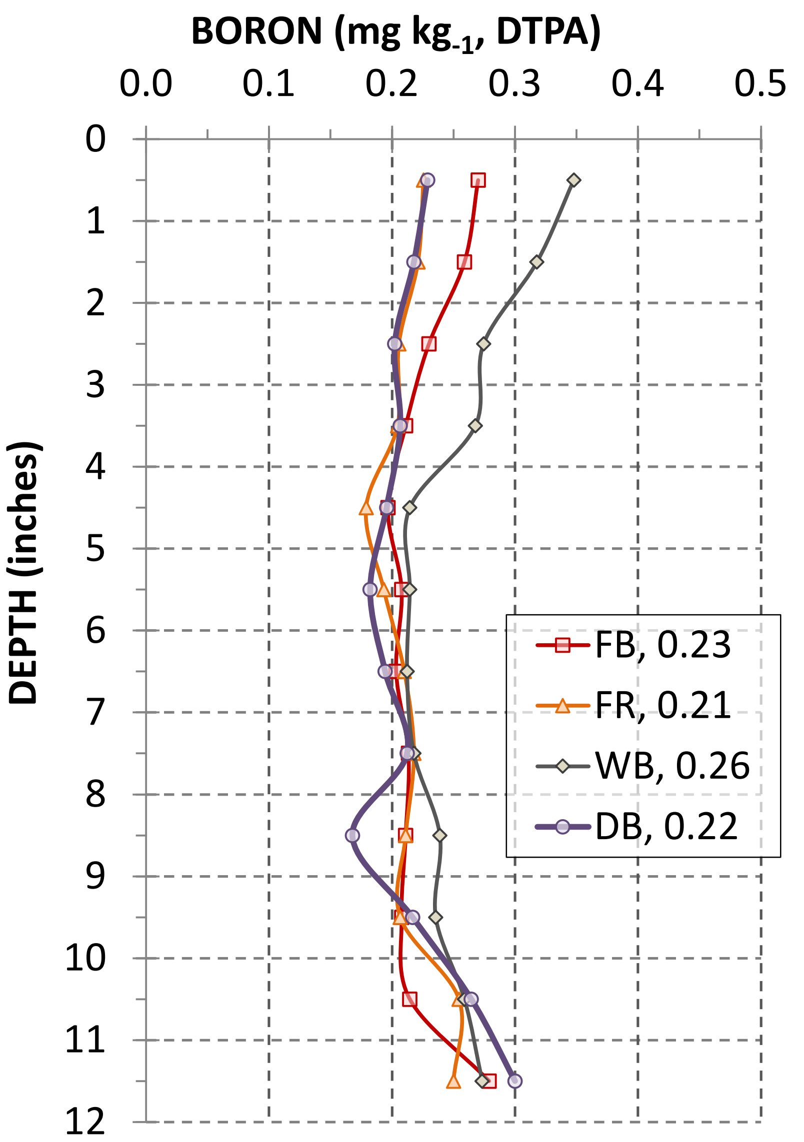
Nutrient Status. Extractable Boron

Observations. Significant differences across treatments and soil depths from zero to four inches. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([B], %)

SAMPLE	FB	FR	WB	DB
GRAIN	3.7 a	3.7 a	3.8 a	3.6 a
STRAW	4.7 a	3.2 a	3.9 a	4.1 a
COVER	1.5 b	3.7 a	2.5 ab	3.8 a
ASH	5.6 a	*NA*	4.5 b	*NA*
FATE OF BIOMASS BORON, B, ratio				
GRAIN	0.35 b	0.38 a	0.33 ab	0.35 ab
COVER	0.15 c	0.62 a	0.25 b	0.20 b
B & B*	0.49 a	0.00 d	0.34 c	0.40 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



Nutrient Status. Chloride

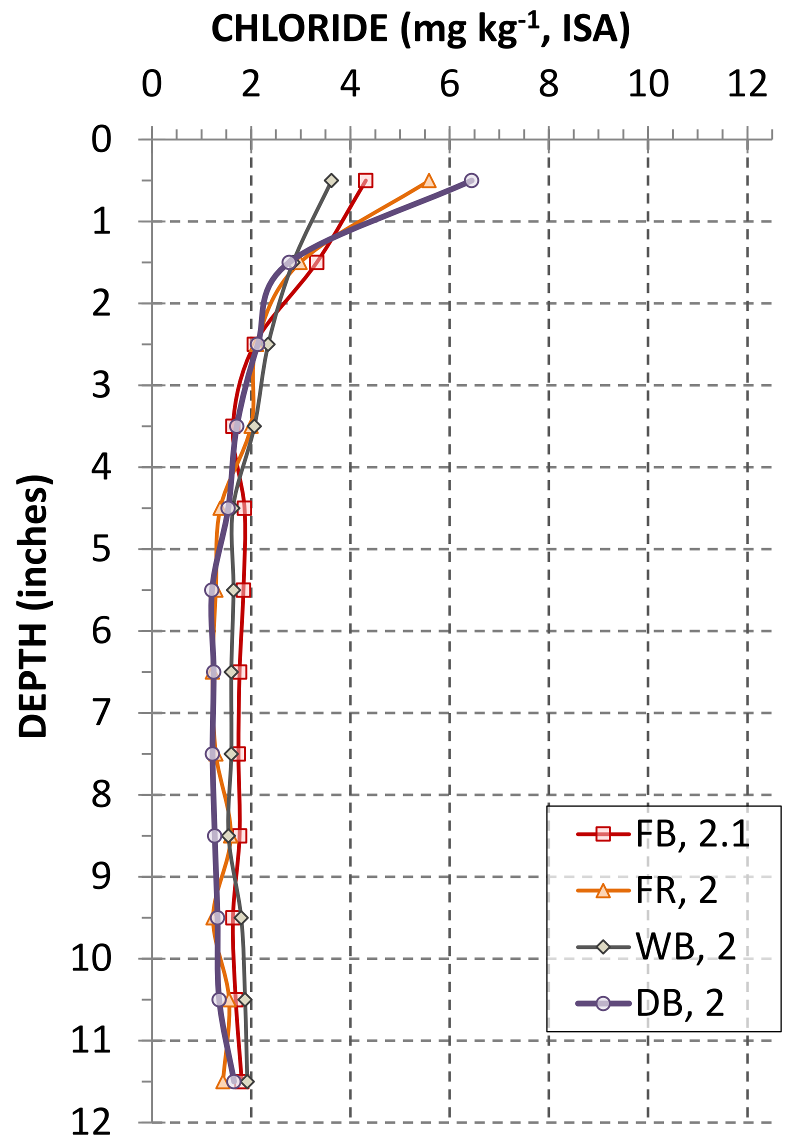
Observations. Significant differences across treatments and soil depths from zero to one inch. Significant differences observed across treatments among biomass partitions.

Biomass Partitions ([Cl], %)

SAMPLE	FB	FR	WB	DB
GRAIN	0.13 a	0.12 b	0.12 b	0.13 b
STRAW	0.28 c	0.28 a	0.31 b	0.17 b
COVER	0.06 c	0.14 ab	0.13 a	0.09 bc
ASH	0.08 b	*NA*	0.22 a	*NA*

FATE OF BIOMASS CHLORIDE, Cl^{-}, ratio				
GRAIN	0.25 a	0.27 a	0.32 a	0.30 b
COVER	0.24 c	5.99 a	1.69 b	0.41 b
B & B*	0.05 c	0.73 a	0.25 b	0.25 b

** B & B = RESIDUE MGT EFFECT, BURN (TRT FB, WB) AND BALE (TRT DB)*



Conclusions

- Burn elevates soil pH, base saturation, and profile distribution of soluble elements
- Burn affects elevated soil temperatures during grain fill (and earlier)
- No-till affects nitrogen and sulfur cycling, and lowers root respiration rates (cooler soils)

Acknowledgments

- Dwelley and David Jones, Walla Walla, WA … Donated time and space, and very generously tolerated numerous inconveniences for sites one and two.
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- Jenny Carlson, lab manager WSU
  - plant issue, ash and soil analysis for C and N