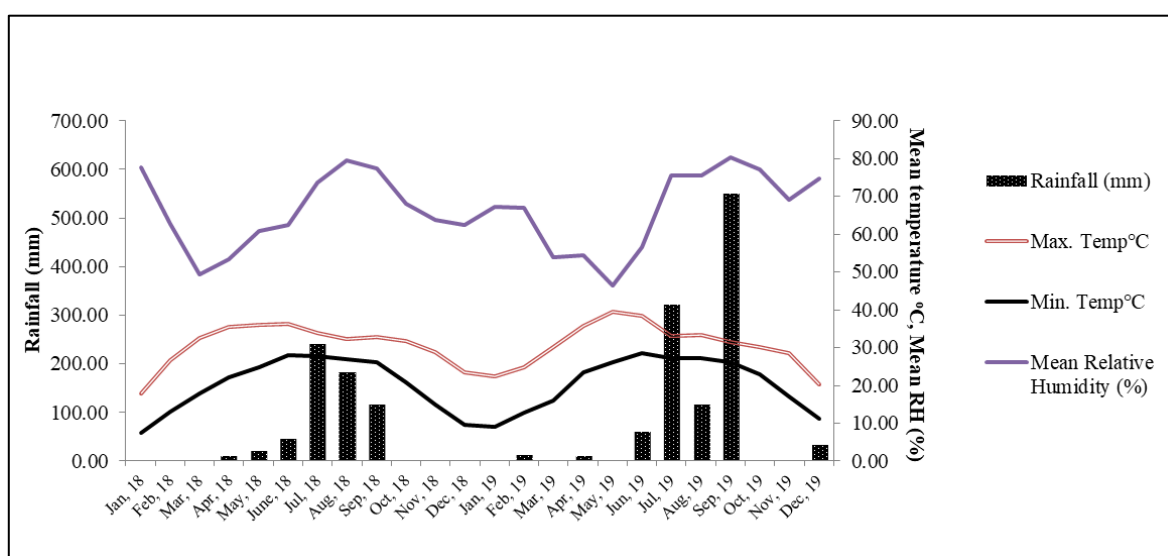


## Supplementary tables and figures



**Figure S1.** Mean monthly meteorological observations during 2018 and 2019.

**Supplementary Table S1** Treatment description of the present experiment.

Treatment abbreviation	Descriptions
ZTDSR <sub>R+</sub> : Zero-tillage direct-seeded rice with residue	Direct seeded rice in zero-tillage with 30% rice residue retention sown at 22.5 cm row spacing by happy seeder. All the pre-established weeds were controlled by pre-sowing application of glyphosate (41% EC).
ZTDSR: Zero-tillage direct-seeded rice	Same as above except residue retention.
CTDSR <sub>R+</sub> : Conventional-till transplanted rice with residue	Conventional tillage (2 dry harrowing + 2 wet tillage + 1 planking) direct seeded rice. 30% rice residues were kept in fields.
CTDSR: Conventional-till transplanted rice	Same as CTDSR <sub>R+</sub> except residue retention.
PTR <sub>R+</sub> : Puddled transplanted rice with residue	Conventional rice transplanting with a row spacing of 20 cm and hill to hill spacing of 15 cm. 30% rice residues incorporated in plots.
PTR: Puddled transplanted rice	Same as PTR <sub>R+</sub> except residue retention.
R+: Residue retention (30%)	

**WSA % (>2 mm) 0-15cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	5.67	0.0098
Crop rotation	4	48	5.20	0.0015
Tillage*Crop rotation	20	48	6.87	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	1.78	0.1457
block	2	10	1.89	0.2016
Crop rotation*block	8	60	0.41	0.9100

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	79.363284	1.78	0.1457
block	2	20.328602	1.89	0.2016
Crop rotation*block	8	36.737909	0.41	0.9100
Tillage	5	152.657822	5.67	0.0098
Tillage*block	10	53.840264	0.48	0.8955
Residual	60	670.652847	.	.

**WSA % (2-0.5mm) 0-15 cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	4.99	0.0150
Crop rotation	4	48	6.77	0.0002
Tillage*Crop rotation	20	48	1.71	0.0647

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	5.69	0.0006
block	2	10	1.21	0.3392
Crop rotation*block	8	60	1.15	0.3431

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	1891.843536	5.69	0.0006
block	2	287.216900	1.21	0.3392
Crop rotation*block	8	765.400835	1.15	0.3431
Tillage	5	2967.389455	4.99	0.0150
Tillage*block	10	1189.830919	1.43	0.1884
Residual	60	4983.568060	.	.

**WSA % (0.5-0.25 mm) 0-15 cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	4.04	0.0287
Crop rotation	4	48	6.08	0.0005
Tillage*Crop rotation	20	48	3.83	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	3.31	0.0163
block	2	10	0.30	0.7488
Crop rotation*block	8	60	0.96	0.4730

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	829.067239	3.31	0.0163
block	2	41.604649	0.30	0.7488
Crop rotation*block	8	483.110940	0.96	0.4730
Tillage	5	1247.075954	3.57	0.0411
Tillage*block	10	698.622293	1.11	0.3666
Residual	60	3760.911423	.	.

WSA%

0.25-0.125mm 0-15 cm

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	2.92	0.0700
Crop rotation	4	48	17.58	<.0001
Tillage*Crop rotation	20	48	13.46	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	3.37	0.0149
block	2	10	6.21	0.0177
Crop rotation*block	8	60	0.19	0.9915

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	713.765869	3.37	0.0149
block	2	77.161508	6.21	0.0177
Crop rotation*block	8	80.176699	0.19	0.9915
Tillage	5	148.434104	4.78	0.0172
Tillage*block	10	62.157941	0.12	0.9995
Residual	60	3178.820917	.	.

WSA%

0.125-0.053mm (0-15cm)

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	0.94	0.4933
Crop rotation	4	48	2.14	0.0897
Tillage*Crop rotation	20	48	2.36	0.0077

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	1.74	0.1532
block	2	10	4.66	0.0372
Crop rotation*block	8	60	2.62	0.0158

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	38.606606	1.74	0.1532
block	2	22.851541	4.66	0.0372
Crop rotation*block	8	116.188262	2.62	0.0158
Tillage	5	21.264183	1.73	0.2144
Tillage*block	10	24.522670	0.44	0.9196

Source	DF	Sum of Squares	F Value	Pr > F
Residual	60	332.933852	.	.

**WSA % >2mm (15-30cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	6.45	0.0063
Crop rotation	4	48	2.56	0.0505
Tillage*Crop rotation	20	48	1.49	0.1301

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	2.05	0.0994
block	2	10	0.54	0.5964
Crop rotation*block	8	60	0.81	0.5950

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	12.765170	2.05	0.0994
block	2	0.809721	0.54	0.5964
Crop rotation*block	8	10.134266	0.81	0.5950
Tillage	5	40.244934	10.82	0.0009
Tillage*block	10	7.436612	0.48	0.8987
Residual	60	93.629515	.	.

**WSA% 2-0.5mm (15-30 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	0.21	0.9519
Crop rotation	4	48	1.54	0.2066
Tillage*Crop rotation	20	48	1.69	0.0698

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	1.20	0.3215
block	2	10	6.19	0.0178
Crop rotation*block	8	60	0.46	0.8769

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	281.466370	1.20	0.3215
block	2	740.799480	6.19	0.0178
Crop rotation*block	8	217.941635	0.46	0.8769
Tillage	5	61.918459	0.21	0.9519
Tillage*block	10	597.911013	1.02	0.4402
Residual	60	3527.161253	.	.

**WSA % 0.5-0.25mm (15-30cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	4.07	0.0281
Crop rotation	4	48	0.77	0.5498
Tillage*Crop rotation	20	48	6.03	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	0.29	0.8839
block	2	10	48.22	<.0001
Crop rotation*block	8	60	0.46	0.8762

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	68.338373	0.29	0.8839
block	2	1866.998088	48.22	<.0001
Crop rotation*block	8	219.618483	0.46	0.8762
Tillage	5	451.501649	4.66	0.0186
Tillage*block	10	193.598353	0.33	0.9704
Residual	60	3545.512106	.	.

**WSA% 0.25-0.125mm (15-30 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	11.68	0.0006
Crop rotation	4	48	8.08	<.0001
Tillage*Crop rotation	20	48	5.36	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	3.23	0.0181
block	2	10	4.33	0.0441
Crop rotation*block	8	60	0.37	0.9341



Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	648.360596	3.23	0.0181
block	2	138.005381	4.33	0.0441
Crop rotation*block	8	147.063796	0.37	0.9341
Tillage	5	1171.295578	14.71	0.0002
Tillage*block	10	159.255734	0.32	0.9735
Residual	60	3008.382645	.	.

**WSA % 0.125-0.053mm (15-30 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	3.69	0.0374
Crop rotation	4	48	0.70	0.5948
Tillage*Crop rotation	20	48	1.96	0.0295

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	0.50	0.7328
block	2	10	2.26	0.1550
Crop rotation*block	8	60	0.65	0.7365

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	39.252698	0.50	0.7328
block	2	40.732314	2.26	0.1550
Crop rotation*block	8	100.486180	0.65	0.7365
Tillage	5	258.401681	5.73	0.0094
Tillage*block	10	90.122701	0.46	0.9072
Residual	60	1167.782973	.	.

**MWD 0-15 cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	3.83	0.0336
Crop rotation	4	48	16.38	<.0001
Tillage*Crop rotation	20	48	7.81	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	5.25	0.0011
block	2	10	6.60	0.0149
Crop rotation*block	8	60	0.74	0.6595

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	0.473003	5.25	0.0011
block	2	0.082060	6.60	0.0149
Crop rotation*block	8	0.132651	0.74	0.6595
Tillage	5	0.138432	4.45	0.0215
Tillage*block	10	0.062203	0.28	0.9842
Residual	60	1.352111	.	.

**E(LT) 0-15cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	8.76	0.0020
Crop rotation	4	48	1.07	0.3838
Tillage*Crop rotation	20	48	2.11	0.0179

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	0.74	0.5705
block	2	10	1.26	0.3263
Crop rotation*block	8	60	0.29	0.9662

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	310.201664	0.74	0.5705

Source	DF	Sum of Squares	F Value	Pr > F
block	2	421.965626	1.26	0.3263
Crop rotation*block	8	245.444185	0.29	0.9662
Tillage	5	7360.041606	8.76	0.0020
Tillage*block	10	1680.591000	1.60	0.1295
Residual	60	6314.000593	.	.

**MWD 15-30 cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	1.68	0.2273
Crop rotation	4	48	6.09	0.0005
Tillage*Crop rotation	20	48	3.99	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	2.92	0.0282
block	2	10	0.39	0.6886
Crop rotation*block	8	60	0.16	0.9951

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	0.096740	2.92	0.0282
block	2	0.003961	0.39	0.6886
Crop rotation*block	8	0.010682	0.16	0.9951
Tillage	5	0.038497	1.51	0.2716
Tillage*block	10	0.051128	0.62	0.7926
Residual	60	0.496428	.	.

**GMD 15-30cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	3.70	0.0373
Crop rotation	4	48	5.59	0.0009
Tillage*Crop rotation	20	48	4.64	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	2.51	0.0510
block	2	10	1.82	0.2113
Crop rotation*block	8	60	0.40	0.9142

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	0.025062	2.51	0.0510
block	2	0.007152	1.82	0.2113
Crop rotation*block	8	0.008052	0.40	0.9142
Tillage	5	0.036247	3.70	0.0373
Tillage*block	10	0.019614	0.79	0.6416
Residual	60	0.149646	.	.

**E(LT) 15-30cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	12.02	0.0006
Crop rotation	4	48	0.68	0.6118
Tillage*Crop rotation	20	48	2.46	0.0055

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	0.44	0.7770
block	2	10	24.31	0.0001
Crop rotation*block	8	60	0.49	0.8591

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	197.324643	0.44	0.7770
block	2	3457.723388	24.31	0.0001
Crop rotation*block	8	435.884027	0.49	0.8591
Tillage	5	4385.755701	12.34	0.0005
Tillage*block	10	711.089100	0.64	0.7749
Residual	60	6680.456384	.	.

**Aggregate associated C >2 mm (0-15 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	41.00	<.0001
Crop rotation	4	48	6.27	0.0004
Tillage*Crop rotation	20	48	2.33	0.0087

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	4.20	0.0046
block	2	10	9.50	0.0049
Crop rotation*block	8	60	0.42	0.9044

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	25.376465	4.20	0.0046

Source	DF	Sum of Squares	F Value	Pr > F
block	2	18.821036	9.50	0.0049
Crop rotation*block	8	5.082058	0.42	0.9044
Tillage	5	207.329353	41.84	<.0001
Tillage*block	10	9.910976	0.66	0.7602
Residual	60	90.706306	.	.

**Aggregate associated C      2-0.5mm (0-15 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	15.11	0.0002
Crop rotation	4	48	5.15	0.0016
Tillage*Crop rotation	20	48	2.15	0.0155

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	4.07	0.0055
block	2	10	0.67	0.5350
Crop rotation*block	8	60	1.49	0.1784

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	24.093471	4.07	0.0055
block	2	2.245588	0.67	0.5350
Crop rotation*block	8	17.683017	1.49	0.1784
Tillage	5	120.248238	14.27	0.0003
Tillage*block	10	16.851743	1.14	0.3493
Residual	60	88.748084	.	.

**Aggregate associated C      0.5-0.25 mm (0-15 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	15.56	0.0002
Crop rotation	4	48	2.78	0.0371
Tillage*Crop rotation	20	48	1.49	0.1299

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	2.43	0.0576
block	2	10	5.47	0.0248
Crop rotation*block	8	60	1.23	0.2996

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	32.318475	2.43	0.0576
block	2	24.690561	5.47	0.0248
Crop rotation*block	8	32.664998	1.23	0.2996
Tillage	5	226.013446	20.03	<.0001
Tillage*block	10	22.562647	0.68	0.7406
Residual	60	199.762764	.	.

**Aggregate associated C      0.25-0.125mm (0-15 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	16.57	0.0001
Crop rotation	4	48	9.22	<.0001
Tillage*Crop rotation	20	48	1.65	0.0783



Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	8.81	<.0001
block	2	10	8.54	0.0069
Crop rotation*block	8	60	2.19	0.0412

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	55.670515	8.81	<.0001
block	2	28.791569	8.54	0.0069
Crop rotation*block	8	27.618580	2.19	0.0412
Tillage	5	139.618730	16.57	0.0001
Tillage*block	10	16.848964	1.07	0.4017
Residual	60	94.775825	.	.

**Aggregate associated C      0.125-0.053 mm (0-15 cm)**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	12.84	0.0004
Crop rotation	4	48	7.23	0.0001
Tillage*Crop rotation	20	48	1.44	0.1502

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	7.40	<.0001
block	2	10	11.00	0.0030
Crop rotation*block	8	60	2.69	0.0135

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	41.979365	7.40	<.0001

Source	DF	Sum of Squares	F Value	Pr > F
block	2	22.859689	11.00	0.0030
Crop rotation*block	8	30.516606	2.69	0.0135
Tillage	5	93.177203	17.93	0.0001
Tillage*block	10	10.395427	0.73	0.6907
Residual	60	85.105574	.	.

**Aggregate associated C >2mm 15-30 cm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	21.22	<.0001
Crop rotation	4	48	5.76	0.0007
Tillage*Crop rotation	20	48	9.32	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	1.58	0.1919
block	2	10	17.31	0.0006
Crop rotation*block	8	60	0.52	0.8375

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	13.455600	1.58	0.1919
block	2	57.763372	17.31	0.0006
Crop rotation*block	8	8.854797	0.52	0.8375
Tillage	5	177.003920	21.22	<.0001
Tillage*block	10	16.686438	0.78	0.6451
Residual	60	127.933829	.	.

**Aggregate associated C 15-30 cm 2-0.5mm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	16.59	0.0001
Crop rotation	4	48	2.41	0.0617
Tillage*Crop rotation	20	48	1.29	0.2333

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	2.01	0.1048
block	2	10	8.07	0.0082
Crop rotation*block	8	60	0.20	0.9899

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	13.349340	2.01	0.1048
block	2	21.707899	8.07	0.0082
Crop rotation*block	8	2.646952	0.20	0.9899
Tillage	5	114.709602	17.07	0.0001
Tillage*block	10	13.441458	0.81	0.6211
Residual	60	99.721360	.	.

**Aggregate associated C 15-30 cm 0.5-0.25 mm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	16.17	0.0002
Crop rotation	4	48	2.23	0.0800
Tillage*Crop rotation	20	48	1.24	0.2628

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	1.82	0.1377
block	2	10	30.84	<.0001
Crop rotation*block	8	60	0.48	0.8636

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	9.298001	1.82	0.1377
block	2	29.183937	30.84	<.0001
Crop rotation*block	8	4.946782	0.48	0.8636
Tillage	5	84.371349	35.67	<.0001
Tillage*block	10	4.730814	0.37	0.9551
Residual	60	76.829251	.	.

**Aggregate associated C 15-30 cm 0.25-0.125mm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	3.74	0.0362
Crop rotation	4	48	0.82	0.5208
Tillage*Crop rotation	20	48	0.53	0.9401

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	1.05	0.3891
block	2	10	8.61	0.0067
Crop rotation*block	8	60	1.91	0.0751

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	4.201713	1.05	0.3891

Source	DF	Sum of Squares	F Value	Pr > F
block	2	37.047593	8.61	0.0067
Crop rotation*block	8	15.275041	1.91	0.0751
Tillage	5	40.177725	3.74	0.0362
Tillage*block	10	21.507955	2.15	0.0338
Residual	60	60.011681	.	.

**Aggregate associated C 15-30 cm 0.125-0.053mm**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Tillage	5	10	3.62	0.0394
Crop rotation	4	48	3.98	0.0072
Tillage*Crop rotation	20	48	0.46	0.9704

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Crop rotation	4	60	5.09	0.0013
block	2	10	3.58	0.0671
Crop rotation*block	8	60	1.64	0.1333

Source	DF	Sum of Squares	F Value	Pr > F
Crop rotation	4	22.805590	5.09	0.0013
block	2	20.530660	3.58	0.0671
Crop rotation*block	8	14.658627	1.64	0.1333
Tillage	5	51.911070	3.62	0.0394
Tillage*block	10	28.647389	2.56	0.0120
Residual	60	67.147386	.	.