Thermal properties and combustion related problems prediction of agricultural crop residues

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Supplemental Materials

Table S1. Fuel and Ash Analysis along with HHV Results of Agricultural Crop Residues

No.	Type	C (wt%)	H (wt%)	O (wt%)	N (wt%)	S (wt%)	Cl (wt%)	Ash (wt%)	K (mg/kg)	Na (mg/kg)	Si (mg/kg)	P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	HHV (MJ/kg)	Reference
1	WS	46.60	6.00	-	0.40	913 mg/kg	2300 mg/kg	4.5	6970	201	11100	385	3010	688	-	Sommersacher, 2013
2	WS	44.90	5.60	-	0.60	1485 mg/kg	3046 mg/kg	6.6	6629	282.9	17618	442	3785	945	-	Sommersacher, 2013
3	WS	27.30	49.00	22.14	0.47	0.04	0.0542	-	0.19%	0.04%	0.65%	0.01%	0.03%	0.04%	-	Blander, 1997
4	WS	40.67	4.89	35.56	0.49	0.11	0.1	5.08	35219	-	-	-	28517	7245	16.03 (HHV), 14.64 (LHV)	Bradna, 2016
5	WS	51.67	6.21	40.45	1.44	0.23	8.25%	14.8	20.90%	0.60%	53.00%	2.78%	7.46%	3.59%	-	Xue, 2020
6	WS	44.80	5.51	40.20	0.65	0.05	0.31	5.2	6700	-	-	0.05%	-	-	17.7 (HHV), 16.4 (LHV)	Pesenjanski, 2016
7	WS	44.92	5.46	41.77	0.44	0.16	0.23	7.02	25.60%	1.71%	55.32%	1.26%	6.14%	1.06%	17.94 (HHV)	Jekins, 1998
8	WS	44.80	7.01	-	0.56	0.17	-	6.04	1.75%	0.06%	3.01%	-	0.27%	0.13%	-	Li, et al., 2007
9	WS	41.31	5.78	50.98	-	0.72	1.78%	13.65	16.12%	-	33.37%	4.23%	20.68%	8.50%	-	Wang, 2018
10	WS	39.99	5.15	38.96	0.30	0.10	-	2.688	56.07%	3.99%	2.08%	14.11%	14.87%	4.35%	21.156(HHV), 18.31 (LHV)	Zhang, 2014
11	WS	49.00	5.94	43.70	0.77	0.17	0.544	7.1	-	-	-	-	-	-	19.555 (HHV), 18.181 (LHV)	Bakker, 2013
12	WS	45.70	6.00	40.90	1.40	0.16	0.74	5.8	1.51	0.07	1.29	0.13	0.23	0.06	18.4 (HHV)	Trinh, 2013
13	WS	37.20	5.57	37.30	1.14	0.20	-	17.04	-	-	-	-	-	-	14.86 (HHV)	Montero, 2016

14	WS	45.50	5.10	34.10	1.80	-	-	13.5	-	-	-	-	-	-	17.0 (HHV)	Demirbas, 1997
15	WS	41.60	6.10	52.10	0.14	0.06	-	1.3	-	-	-	14381ppm	-	22534ppm	20.3 (HHV)	Naik, 2010
16	WS	42.95	5.35	46.99	-	-	-	6.9	-	-	-	-	-	-	17.99 (HHV)	Yin, 2011
1	RS	43.30	6.00	39.10	0.40	0.20	83.6 g/kg	-	230.7 g/kg	3.5 g/kg	-	14.8 g/kg	18.6 g/kg	21.4 g/kg	17.249 (HHV), 15.931 (LHV)	Baetge, 2018
2	RS	45.10	6.20	32.10	0.60	0.30	57.3 g/kg	-	226.5 g/kg	13.3 g/kg	-	20.1 g/kg	39.4 g/kg	11.6 g/kg	17.330 (HHV), 15.968 (LHV)	Baetge, 2018
3	RS	38.24	5.20	36.26	0.87	0.18	0.58	18.67	12.30%	0.96%	74.67%	1.41%	3.01%	1.75%	15.09 (HHV)	Jekins, 1998
4	RS	49.50	6.20	41.50	0.20	0.10	0.02	0.4	0.05%	1.90%	75%	2.70%	1.50%	1.90%	18.0 (HHV)	Liu et al., 2011
5	RS	40.30	5.10	45.10	0.50	0.09	0.61	15	15.30%	0.40%	69.90%	1.50%	3.50%	1.60%	14.7 (LHV)	Skrifvars, 2005
6	RS	48.70	5.92	44.20	1.05	0.14	0.49	18.0	-	-	-	-	-	-	18.824(HHV), 17.511 (LHV)	Bakker, 2013
7	RS	37.19	4.80	57.60	0.20	0.30	-	6.9	-	-	-	-	-	-	12.3 (HHV)	Nizamuddin, 2019
8	RS	44.40	7.40	47.07	1.13	0.00	-	13.3	19350.0	860.8%	39310	940.6	4917	4074	15.03 (HHV), 13.58 (LHV)	Duan, 2015
9	RS	33.70	3.91	36.26	0.71	0.03	0.3	13.3	-	-	-	-	-	-	14.08 (HHV)	Hung, 2020
10	RS	46.24	6.21	46.23	1.32	-	-	-	-	-	-	-	-	-	16.16 (HHV)	Huang, 2012
11	RS	28.55	3.98	65.71	1.15	0.61	-	20.0	-	-	-	-	-	-	13.48 (HHV)	Danish, 2015
12	RS	42.04	6.26	39.00	1.23	0.64	-	10.83	38.92%	2.16%	44.72%	1.63%	9.23%	1.96%	19.441 (LHV)	Okasha, 2007
13	RS	42.57	5.84	49.33	2.13	0.13	0.6	9.2	1.131wt%	0.540wt%	2.082wt%	-	0.12wt%	0.068wt%	-	Kai, 2019
14	RS	41.25	5.59	36.71	1.12	0.16	10.63%	9.6	34.55%	5.81%	39.28%	1.73%	0.85%	3.76%	-	Pan, 2020
15	RS	41.15	6.93	50.71	0.97	0.24	0.39	15.6	1.13wt%	0.05wt%	2.29wt%	0.21wt%	3.4wt%	0.12wt%	-	Xue, 2017
16	RS	47.92	6.27	44.38	1.17	0.26	0.34	13.9	2.26wt%	-	4.14wt%	0.10wt%	0.64wt%	0.21wt%	-	Zhang, 2012
17	RS	39.01	6.59	-	0.64	-	-	16.81	-	-	-	-	-	-	14.17 (HHV)	Said,2013
18	RS	40.64	6.80	-	0.40	-	-	15.52	-	-	-	-	-	-	14.67 (HHV)	Said,2013
19	RS	37.74	6.49	-	1.23	-	-	18.66	-	-	-	-	-	-	14.06 (HHV)	Said,2013
20	RS	41.24	6.99	-	0.63	-	-	13.25	-	-	-	-	-	-	14.96 (HHV)	Said,2013
1	RH	38.83	4.75	35.47	0.52	0.05	0.12	20.26	3.71%	0.21%	91.42%	0.43%	3.21%	0.01%	15.84(HHV)	Jenkins, 1998
2	RH	42.80	6.20	37.00	0.70	0.20	7.9 g/kg	-	35.0 g/kg	2.7 g/kg	-	10.4 g/kg	14.2 g/kg	6.3 g/kg	17.920 (HHV), 16.558 (LHV)	Baetge, 2018

3	RH	41.10	6.00	39.80	0.40	0.30	10.9 g/kg	-	35.1 g/kg	2.4 g/kg	-	58.1 g/kg	11.0 g/kg	9.2 g/kg	17.517 (HHV), 16.199 (LHV)	Baetge, 2018
4	RH	43.50	6.00	37.80	0.40	0.20	6.9 g/kg	-	30.1 g/kg	2.5 g/kg	-	7.6 g/kg	10.8 g/kg	6.0 g/kg	17.774 (HHV), 16.456 (LHV)	Baetge, 2018
5	RH	40.10	4.70	54.50	0.50	0.05	0.06	19.7	1.85%	0.01%	95.65%	0.55%	0.50%	0.30%	15.5 (LHV)	Skrifvars, 2005
6	RH	40.23	5.23	37.51	-	-	-	15.1	-	-	-	-	-	-	15.2 (HHV)	Shen, 2012
7	RH	39.09	5.44	29.69	0.50	0.05	-	13.150	1.00%	2.14%	92.92%	0.34%	0.22%	0.24%	17.42 (HHV)	Park, 2005
8	RH	38.24	5.56	32.13	0.37	0.04	-	13.500	0.85%	0.87%	86.21%	0.29%	0.27%	0.27%	17.51(HHV)	Park, 2005
9	RH	37.77	5.29	31.66	0.31	0.02	-	15.440	0.99%	1.06%	90.55%	0.31%	0.28%	0.28%	16.52 (HHV)	Park, 2005
10	RH	37.31	5.58	30.08	0.27	0.00	-	17.110	0.63%	0.40%	87.88%	0.19%	0.30%	0.21%	16.31 (HHV)	Park, 2005
11	RH	36.75	5.45	31.18	0.37	0.03	-	16.440	0.87%	0.94%	87.60%	0.27%	0.28%	0.28%	16.25 (HHV)	Park, 2005
12	RH	36.61	5.43	34.23	0.34	0.03	-	13.340	0.77%	0.40%	87.39%	0.18%	0.20%	0.16%	16.6 (HHV)	Park, 2005
13	RH	32.74	5.84	37.16	0.32	0.02	-	13.480	0.76%	0.71%	89.92%	0.32%	0.28%	0.29%	15.98 (HHV)	Park, 2005
14	RH	38.27	5.74	30.20	0.29	0.02	-	15.650	0.83%	0.54%	90.96%	0.21%	0.39%	0.30%	16.68 (HHV)	Park, 2005
15	RH	38.50	5.20	34.61	0.45	-	-	21.240	-	-	-	-	-	-	14.69 (HHV)	Yin, 2011
16	RH	38.20	5.60	33.70	-	-	-	22.500	-	-	-	-	-	-	16.47 (HHV)	Yin, 2011
17	RH	38.20	3.15	41.38	0.89	0.19	-	16.2	2%	-	96%	-	1%	0%	11.66 (LHV)	Yang, 2017
18	RH	42.30	6.10	37.50	1.10	0.04	0.2	12.8	5.4%	0.2%	87.7%	3.7%	1.3%	0.8%	15.0 (LHV), 16.3 (HHV)	Armesto, 2002
1	CS	43.11	5.73	42.42	0.92	0.31	-	7.51	14682	334	-	-	5980	4173	17.19 (HHV)	Zhang, 2018
2	CS	44.79	5.48	44.30	0.34	0.04	0.06	2.1	-	-	-	-	-	-	18.49 (HHV)	Poudel, 2014
3	CS	43.56	5.86	46.35	1.14	0.35	-	-	15283	2028	-	1.02	4600	4100	-	Lu, 2014
4	CS	44.16	5.85	45.99	1.18	0.37	-	-	12615	1706	-	3.08	3700	2700	-	Lu, 2014
5	CS	39.15	5.88	49.44	1.61	0.38	-	-	17333	1450	-	2.4	6700	4200	-	Lu, 2014
6	CS	48.90	6.01	44.40	0.61	0.05	0.41	6.6	18.89%	-	43.04%	0.57%	12.36%	7.96%	18.06 (HHV), 16.84 (LHV)	Danje, 2011
7	CS	47.40	5.01	38.09	0.77	0.31	-	8.18	-	-	-	-	-	-	18.45 (HHV)	Kumar, 2008

8	CS	44.73	5.87	40.44	0.60	0.07	0.64	7.65	16.10%	0.14%	36.70%	2.10%	12.80%	3.90%	17.68 (HHV), 16.4 (LHV)	Masia, 2007
9	CS	43.70	5.56	43.30	0.61	0.01	0.6	5.6	-	-	-	-	-	-	-	Kumar, 2008
10	CS	39.81	5.08	47.37	0.94	0.23	12.68 %	6.58	46.73%	-	18.18%	7.55%	7.12%	4.59%	13.49(LHV)	Yang, 2017
11	CS	45.48	5.52	41.52	0.69	0.04	984 ug/g	6.73	20.22%	1.47%	54.12%	1.97%	5.61%	4.22%	17.93 (HHV), 16.73 (LHV)	Morey, 2009
12	CS	45.70	6.00	42.00	0.60	0.09	0.36	5.3	8100	120	8300	690	3500	3700	18.12 (HHV), 16.82 (LHV)	Xiong, 2008
13	CS	41.09	6.85	-	1.62	0.20	-	3.85	1.85wt%	0.08%	2.49%	-	0.50%	0.50%	-	Li, et al., 2007
14	CS	33.52	5.67	54.69	0.52	0.07	-	5.53	-	-	-	-	-	-	17.31 (HHV)	Tumuluru, 2012
15	CS	43.92	6.01	40.44	0.42	0.07	-	5.13	-	-	-	-	-	-	17.31 (HHV)	Tumuluru, 2015

Note: WS = wheat straw, RS = rice straw, RH = rice husk, CS = corn stalk, HHV = Higher Heating Value, LHV = Lower Heating Value.

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