ANTROPOGENIC AND NATURAL PYROGENIC CARBON IN TROPICAL ENVIRONMENTS: FROM THE RHIZOSPHERE TO THE LANDSCAPE

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ANTROPOGENIC AND NATURAL PYROGENIC CARBON IN TROPICAL ENVIRONMENTS: FROM THE RHIZOSPHERE TO THE LANDSCAPE

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Despite an increasing body of literature, the interactions of pyrogenic carbon (PyC) in the environment are not as well understood as other forms of C. This dissertation focused on generating knowledge of the interactions of (PyC) in tropical terrestrial ecosystems. Main areas of concentration include 1. Investigations into the mechanisms driving increased biological nitrogen fixation (BNF) in common bean (*Phaseolus vulgaris*) following the additions of anthropogenic PyC to agricultural soil, 2. Evaluating the differing ability of pyrolyzed and non-pyrolyzed crop residues to protect introduced strains of rhizobium against soil water deficit, and 3. Tracing the movement of natural PyC through the landscape and waterways following land-use change from forested ecosystems to intensive agricultural lands. Biological N fixation and nodule biomass increased by up to twenty-fold and thirty six-fold, respectively, following additions of anthropogenic PyC. This change was linked to greater plant-P uptake (r^2=0.22; P<0.0001, n=201). However, plant P uptake was not correlated with biochar P additions (P>0.05). Improved P nutrition likely resulted from 360% greater mycorrhizal colonization with biochar additions. When microbial inoculants were introduced to soil using pyrolyzed and non-pyrolyzed biomass, DNA fingerprinting of the root nodules indicated that nodule occupancy was dominated by native rhizobium and not the introduced strain. However, measured nodule occupancy (1-38%) of the introduced CIAT899 rhizobial strain by beans was significantly greater than expected

values based on application rates (2-7%), irrespective of carrier. When natural terrestrial PyC was traced in stream water catchments following land-use change, up to 60% losses of the initial PyC stocks occured in the first 10 years after conversion from forest from mineralization and/or erosion. However, PyC was not preferentially eroded relative to total C or non-PyC C. This was true even when scaled to the entire river watershed where PyC concentrations in the headwaters and outlet into Lake Victoria were 3.8 and 3.5% of total C, respectivley . Pyrogenic C enrichment was found with depth in the soil profile from 5% of OC in the topsoil (0-0.15 m) to 23% of OC at 1-2 m.

BIOGRAPHICAL SKETCH

David was born and raised in Santa Barbara, California. He received his Bachelors of Science degree from California Polytechnic State University in Soil Science and Crop Science. While attending university he became involved in organic and alternative farming systems in temperate and tropical environments. David began his graduate program in Soil Science at Cornell University in 2008 under the supervision of Dr. Johannes Lehmann. For his masters work David focused on the use of biochar as a soil fertility amendment in upstate New York and in the equatorial highlands of western Kenya. For his doctoral work David focused on the interactions between pyrogenic carbon and rhizobiology in East African agricultural systems and on the movement natural pyrogenic carbon following land-use change in East Africa. David is married to Bethany Güereña. Their children are Levi Thomas Güereña and Clementine Adia Güereña.

This work is dedicated to Bethany Güereña, my wife and friend. You have taught me how to be successful in my studies and in life and have given me the gift of family. The debt of gratitude that I owe you is immeasurable. Thank you, I love you!

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I would like to thank my advisors, Dr. Johannes Lehmann and Dr. Janice Thies, Dr. David Lee, and Dr. Todd Walter for their guidance in this endeavor. I would also like to thank all of the members of the Lehmann lab and friends and colleagues at the World Agroforestry Centre, particularly Mrs. Hellen Ochieng and Mr. Georges Aertssen. In Kenya, I would like to thank the invaluable assistance of the research technicians Mzee Elphas Okonda, Otieno Owuor, Zablon Khatima, Daniel Okata, Holiance Odiwour, Viddah Wasonga, Reymond Otieno, and Henry Biwott. Without their assistance this work would not have been possible. Most of all I would like to thank Bethany Guerena for her continuing unceasing support, but most of all for putting up again with her vagabond husband.

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CHAPTER 1

PARTITIONING THE CONTRABUTIONS OF BIOCHAR PROPERTIES TO ENHANCED BIOLOGICAL NITROGEN FIXATION IN COMMON BEAN

Abstract

Several studies document increases in biological nitrogen fixation (BNF) following applications of biochar. However, the underlying mechanisms for this response remain elusive. A greenhouse experiment was conducted to test the effects of biochar mineral nutrients, pH, and volatile matter (VM) on BNF in common beans (*Phaseolus vulgaris L.*). Biochars were produced from seven feedstocks pyrolyzed at either 350 or 550°C. Biochars were either treated with acid to reduce mineral nutrient contents, with acetone to remove acetone-soluble VM, with steam to reduce both the mineral and VM contents, or left untreated. The biochar additions at a rate of 15 t ha^{-1} resulted in an average 262% increase in shoot biomass, 164% increase in root biomass, 3575% increase in nodule biomass and a 2126% increase in Ndfa over the control. Simple mineral nutrients and soil acidity amelioration from the biochar were only to a minimal extent responsible for these increases (r^2=0.03; P=0.0298, n=201). Plant growth and Ndfa were more strongly correlated with plant P uptake (r^2=0.22; P<0.0001, n=201). However, plant P uptake was not correlated with biochar P additions (P>0.05). Improved P nutrition likely resulted from 360% greater mycorrhizal colonization with biochar additions. Removal of acetone-soluble VM increased plant growth and Ndfa, and VM extracted from the biochar produced at 350°C reduced the growth of rhizobia in Yeast Extract Mannitol Agar (YMA) medium. In contrast, acetone-soluble VM extracted from seven biochars produced at

550°C increased the growth of rhizobium in the YMA compared to an acetone-residue control, suggesting differential effects of VM forms on rhizobia

Introduction

Biological nitrogen fixation (BNF) is a critically important biological process that has a profound influence on nitrogen (N) cycling, soil fertility, and agricultural productivity. Mutualisms that result in BNF rely on an intricate interaction between the host legume and associated bacteria species collectively termed rhizobia. These mutualistic relationships are sensitive to a multitude of soil constraints, including soil nutrient limitations (Graham and Vance 2003), soil acidity (Graham 1992; Hungria and Vargas 2000), and soil water status (Bordeleau and Prevost 1994; Giller and Cadisch 1995; Sprent 1972) and biotic factors (Peoples et al. 2009). In sub-Saharan Africa, tropical environmental conditions, old and highly weathered soils, and relatively little synthetic fertilizer use have led to systemic underperformance of legumes in smallholder farming systems (Jansa et al. 2011). In these systems, BNF is a primary strategy used to improve soil fertility while legume crop provides a major portion of protein in the human (Broughton et al. 2003) as well as livestock feed. Biological N fixation in the legume/rhizobium symbiosis can be increased by applying lime to alleviate soil acidity (Ledgard and Steele 1992), applying fertilizers to reduce key nutrient deficiencies (e.g., phosphorus (P) (Jansa et al. 2011), and enhancing the potential of the rhizobia-legume symbiosis (Kahindi et al. 1997; Thies and Rillig 2009). One possible method to alter soil properties to increase BNF may be applying biochar to the soil (Rondon et al. 2007).

Biochar is a co-product of the thermal decomposition of organic material in a low-oxygen environment (pyrolysis). Biochar contains condensed structural carbon (C), ash, and residual volatile matter (VM) in varying quantities based largely on feedstock used, time and temperature of pyrolysis (Keiluweit et al. 2010). Increasingly more agronomic studies on biochar are being published though very few of these studies have targeted BNF in legumes following applications of biochar (Rondon et al. 2007; Tagoe et al. 2008) and none has demonstrated the mechanisms by which biochar influenced BNF. Potential mechanisms include: (i) nutrients added from the ash within biochar may alleviate plant and microbial nutritional deficiencies or cause toxicity (Rondon et al. 2007), (ii) changes in nutrient cycles (especially soil N) may increase or decrease the incentive to fix atmospheric N_2 (Rondon et al. 2007), (iii) liming effects from biochar (often a higher pH in many biochars) may modify soil pH positively or negatively for BNF (Warnock et al. 2007; Lehmann et al. 2011), (iv) the adsorptive capacity of biochar may alter the biochemical signaling processes necessary to establish the symbiosis (Lehmann et al. 2011), and (v) certain compounds in the VM on biochar might stimulate or reduce soil microbial activity (Graber et al. 2010; Thies and Rillig 2009).

Physical and chemical properties of biochar produced from a variety of feedstocks and production conditions have been found to vary widely (Enders et al. 2012; Keiluweit et al. 2010; Rajkovich et al. 2011; Schimmelpfennig and Glaser 2012). Several studies have demonstrated a mineral fertilization effect and/or increase in soil pH from biochar additions (Deenik et al. 2011; Van Zwieten et al. 2010).

However, the effects of biochar feedstock and production conditions on BNF are largely unknown, as is the potential influence of the VM.

Organic molecules contained in smoke have been found to enhance seedling germination (Light et al. 2009). Some of these smoke-derived compounds are similar in structure to known microbial signaling molecules (Cesco et al. 2010; Cooper 2007). Other smoke-derived molecular analogues of microbial signaling compounds may be a constituent of the VM in biochar. If present, these molecules might have a stimulatory effect on nodulation and BNF. On the other hand, several studies have also shown a high adsorptive capacity of biochar for various organic molecules, such as pesticides (Yang and Sheng 2003; Hale et al. 2011). If plant and microbial signaling molecules are also adsorbed to the surfaces of biochar particles, this could reduce nodulation and potentially reduce BNF.

The objectives of the work presented here were to (i) quantify the effects of addition of contrasting biochars to a low-fertility soil on BNF of common bean, and (ii) partition the effects of nutrients added and/or adsorption and release of organic molecules on BNF. The hypotheses tested were that (i) fertilization effects of the biochar added may only in part lead to increased BNF, and (ii) the VM of biochar will have a stimulatory effect on nodulation and Ndfa.

Methods

Biochar production

Biochar was produced for two greenhouse experiments, Experiment 1 and Experiment 2. Sugarcane bagasse (*Saccharum* spp.), *Eucalyptus saligna* wood, *Delonix regia* wood, prunings of the tea bush (*Camelia sinensis*), maize (*Zea mays*) stover, and maize cobs (*Z. mays*) were collected as biochar feedstocks from western Kenya during June and July of 2010. Rice hulls (*Oryza sativa*) were acquired from Lundberg Family Farms (Richvale, CA, USA). All feedstocks were air-dried and ground to pass through a 1-mm sieve prior to pyrolyzing. The ground feedstocks were pyrolyzed in bench-top pyrolysis units at either 350 or 550˚C. Two pyrolysis units were used for producing the biochar. One pyrolysis unit (Experiment 1) was based on a modified Fisher Scientific Isotemp programmable muffle furnace (Thermo Fisher Scientific, Waltham, MA, USA). A mild-steel cylinder (pyrolysis chamber) was placed inside the furnace chamber. A 6.35-mm (outer diameter) stainless steel tube was wrapped around the mild-steel cylinder to pre-heat sweep gases and then inserted into the cylinder using a 6.35-mm stainless steel compression fitting. The other end of the stainless steel tube exited the furnace to allow either the sweep gas or deionized water to be injected into the pyrolysis chamber. This pyrolysis unit was used at Cornell University to manufacture the biochar for Experiment 1. All of the biochars manufactured in this kiln were prepared using argon sweep gas at a rate of 1 L min^{-1} to maintain anaerobic conditions during pyrolysis.

A second pyrolysis unit was manufactured for the production of the biochar for Experiment 2. This pyrolysis unit was custom built using high-temperature refractory brick and electric heating coils connected to a programmable temperature controller. The interior metal cylinder of this unit was designed in the same fashion as for the unit from Experiment 1. Oxygen-limited conditions in the pyrolysis chamber were maintained using a steam sweep at a rate of 500 mL min^{-1} injected once the maximum temperature had been reached. During pyrolysis a motorized paddle assembly continuously agitated the feedstock for the duration of production. A ramp temperature rate of 5˚C min^{-1} and a maximum temperature dwell time of 2 h before cooling were used.

Modification of biochars

For each pyrolysis temperature and feedstock combination a subsample of the biochar produced was treated either in the kiln after the maximum kiln temperature had been reached or after the biochar was removed from the kiln. After pyrolysis, one subsample of each biochar produced was leached with acetone using a biochar to acetone ratio of 1:10 (w/v) intended to remove acetone-soluble VM or a fraction of VM that may stimulate plant growth. Each biochar was mixed with acetone and shaken overnight on a reciprocal shaker in a 10-L screw-top Nalgene™ (Thermo Fisher Scientific) canister. After shaking, the mixture was filtered through a Whatman #42 filter paper (Whatman Inc., Piscataway, NJ, USA) placed in a ceramic Buchner funnel and then dried in an oven overnight at 90˚C to evaporate any remaining acetone.

After pyrolysis another sub-sample of each biochar was leached with 2N hydrochloric acid (HCl) to reduce its ash and mineral contents. These biochar subsamples were mixed with 2N HCl at a ratio of 1:10 (w/v), shaken overnight in 10-L screw-top Nalgene™ (Thermo Fisher Scientific) canisters on a reciprocal shaker, and filtered through a Whatman #42 (Whatman Inc.) filter paper placed in a ceramic Buchner funnel. The biochar subsamples were then mixed with de-ionized water in a ratio of 1:10 (w/v) and allowed to equilibrate while being stirred continuously. The pH of each HCl-treated biochar subsample was readjusted to its original pH using sodium hydroxide (NaOH) pellets and a 1N NaOH solution. The biochar subsamples were then filtered again through a ceramic Buchner funnel and leached with deionized water using 1 L per 600 g biochar to remove excess sodium. The HCl/NaOH treated biochar subsamples were then placed in an oven at 60°C until all of the water evaporated.

During pyrolysis one batch of each biochar was treated with steam for 2 h intended to reduce both the VM and the ashed minerals. Steam is used as an activation treatment to remove VM and ash in the process of manufacturing activated carbon (Ioannidou and Zabaniotou 2007; Stuart 1950; Wigmans 1989). Deionized water was injected into the pyrolysis unit once the furnace had reached maximum temperature. The water was injected at a rate of 10 mL min^{-1} for 2 h. A final batch of each biochar was left untreated. Biochar properties from Experiment 1 are presented in Table 1.S1 and Table 1.S2.

For Experiment 2, only two biochar feedstocks were used, *Eucalyptus saligna* and *Delonix regia*, and pyrolyzed only at 550˚C. One subset of biochar from each of the these feedstocks was left untreated. A second set of biochar was treated with HCl following the protocol described in the preceding paragraph and the final pH was adjusted to the original pH of the biochar. A third set of biochar from these feedstocks was treated with HCl as mentioned above and left at low final pH values. Chemical properties from these biochars are presented in Table 1.S3.

Soil and experimental setup

Both greenhouse experiments were established at the World Agroforestry Centre in Kisumu, Kenya, using four replicates. Experiment 1 was conducted in June 2011 and Experiment 2 was conducted as a follow-up in August of 2013. A humic Acrisol was collected from a site that had been converted to agriculture in 1900 (Kimetu et al. 2008; Ngoze et al. 2008; Kinyangi 2007). The field site was in Kapsengere village in western Kenya. The cropping system in the area is dominated by maize and common bean (*P. vulgaris*) production. The soil was air-dried, passed through a 2-mm sieve, and thoroughly homogenized. Soil properties are given in Table 1.1. This soil was used for both experiments.

Table 1.1 Selected soil chemical properties of a humid Acrisol from western Kenya.

pH $CaCl_2$	pH H_2O	CEC† ($mmol_c$ kg^{-1})	$NO_3^{-‡}$	$NH_4^{+‡}$	P§	K#	Ca#	Mg# (mg kg^{-1})	Mn#	Fe#	Cu#	Al#
5.5	6.1	395	3	6	27	4	25	2	8	1	0	5

†Cation exchange capacity NH_4OAc pH7, ‡2N KCl extraction, §Olsen-P, #Mehlich-3

In the first experiment each of the prepared biochars was added separately to 2578 g soil at a rate equivalent to 15 t biochar ha^{-1} (33 g per pot) and homogenized along with granular phosphorus (P) added at a rate equivalent to 1 kg P ha^{-1} in the form of triple super phosphate (Mea Fertilizer Ltd., Nairobi, Kenya). Each of the mixed soils was then added to plastic pots (0.17 m diameter by 0.14 m height), filling each pot to within 10 mm of the pot rim. Also included was a control treatment that received P but not biochar.

For Experiment 2, the same weight of soil and biochar was used as listed above. The fertilizer application in this experiment deviated from the initial experiment, as a fertilizer-only control was added. Synthetic fertilizer was added as a control on an equal basis to biochar produced from *Delonix regia* at 550˚C. This feedstock had the greatest total mineral nutrients of the biochars of Experiment 1. Four grams of a fertilizer was prepared with the following mass percentages and added per pot: 20.6% triple super phosphate, 20.5% muriate of potash, 22.5% calcium chloride, 27.5% magnesium sulfate, 0.58% manganese oxide, 0.35% copper sulfate, 0.40% zinc oxide, and 0.15% sodium borate.

Irrigation and management

A drip irrigation system was installed in the greenhouse with one drip emitter per pot (The Drip Store, Vista, CA, USA). All pots were watered to maintain soil moisture at field capacity for the duration of the experiment. Field capacity (70% water-filled pore space) was determined gravimetrically prior to irrigation.

Nodulating and non-nodulating isolines of the common bean (*Phaseolus vulgaris* L.), variety DOR 364 from CIAT (International Center for Tropical Agriculture, Cali, Columbia), were used. The non-nodulating isoline was used to quantify soil ^{15}N uptake values to determine N derived from fixation (Ndfa) via the natural abundance method (Peoples et al. 2009). In Experiment 1, two seeds were planted per pot on 11 July, 2011, and thinned to one plant per pot on 18 July, 2011. The plants were harvested during peak flowering between 15 and 21 August, 2011. Experiment 2 was planted on 7 August, 2013 and harvested between 13 and 17 September, 2013. At harvest, the roots were separated from the shoots, placed into separate paper bags and dried at 60˚C in a forced air oven. Prior to drying, the roots were washed and nodules were separated from the roots and placed in a plastic bag containing silica gel desiccant.

Determination of B-value

The b-value, needed to quantify Ndfa, was determined at Cornell University, Ithaca, NY, USA. Two seeds of the nodulating isoline of *P. vulgaris* cv DOR 364 were placed into plastic pots filled with acid-washed vermiculite using 7 replicates. The pots were placed under growth lamps continuously in a laboratory maintained at 22°C. Plants were watered regularly with an N-free nutrient solution (Peoples et al. 2009). After the radicles emerged, the plants were inoculated with *Rhizobium tropici* strain CIAT899 and maintained under the growth lamps for four weeks. After four weeks, the plants were harvested and the shoots were separated from the roots. The plant tissue was finely ground and used to determine the b-value (Peoples et al. 2009). Ndfa was determined through the following equation [Eq. 1]:

$$\%Ndfa = 100\left[\frac{\left({}^{15}N_{nn} - {}^{15}N_{n}\right)}{\left({}^{15}N_{nn} - b\right)}\right]$$

Where ${}^{15}N_{nn}$ is the ${}^{15}N$ content of the non-nodulating isoline, ${}^{15}N_{n}$ is the ${}^{15}N$ content of the nodulating isoline, and *b* is the ${}^{15}N$ content of the b-value.

Biochar analysis

Subsamples of all biochars prepared were ground with a mortar and pestle and sieved to reach a particle size of 149–850 µm. Each biochar was then analyzed for total nutrient content in duplicate using a modified dry-ashing technique (Enders and

Lehmann 2012). Biochar ash and VM contents were determined in duplicate by proximate analysis using ASTM D1762-84 Chemical Analysis of Wood Charcoal. Organic C (C_{org}) was quantified by pretreating weighed biochar subsamples with 38% HCl in silver capsules (Elemental Microanalysis, Devon, UK). Initial removal of carbonates was achieved by fuming the samples with concentrated HCl to prevent physical loss of the sample. Capsules were held upright in a porcelain spot plate (#60430, CoorsTek, Inc., Golden, CO, USA) and placed on a digestion block preheated to 80°C in a fume cupboard and covered with an inverted Nalgene™ (Thermo Fisher Scientific) bucket. A 40 mL aliquot of 38% HCl was added to a 25 by 150 mm borosilicate tube (#9825-25, Corning Life Sciences, Corning, NY, USA) that was placed into the block under the cover. Samples were fumed overnight and retrieved the next day after all HCl had evaporated. Carbonate decomposition was completed by drop-wise additions of 38% HCl followed by drying at 80°C prior to preparing the silver capsules for analysis. Hydrogen (H) was determined by combustion using a Hekatech HT Oxygen Analyzer interfaced to a PDZ Europa 20–20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire, UK). Total oxygen (O) was derived by subtraction according to the ASTM D1762-84 Chemical Analysis of Wood Charcoal method as follows [Eq. 2]:

$$O\ (\%\ w/w) = 100\% - ash\ (\%\ w/w) - C\ (\%\ w/w) - N\ (\%\ w/w) - H\ (\%\ w/w)$$

The pH of each biochar was determined in 1:20 biochar:deionized water (w/v). A 1.0 ± 0.01 g subsample was weighed directly into separate 60-mL screw-top glass vials. Vials were filled with 20 mL of deionized water and then agitated on an orbital shaker for 1.5 h. Each slurry was then mixed continually with a stir bar while pH was measured. Biochar properties are given in Tables S1.1 and S1.2.

Plant tissue analysis

Each plant sample was ground finely using a ball mill and homogenized. Total mineral nutrient uptake in shoots was determined by digesting tissue subsamples in HNO_3 and H_2O_2 and analyzing the digests on an axially viewed ICP trace analyzer emission spectrometer (Thermo Electron, Waltham, MA, USA). Total N and C in shoot tissues were determined by dry combustion (PDZ Europa ANCA-GSL elemental analyzer, PDZ Europa 20-20 isotope ratio mass spectrometer, Sercon Ltd., Cheshire, UK). Nitrogen isotope ratios ($^{14}N/^{15}N$) in shoot tissues were measured by isotope ratio mass spectrometry (Sercon Ltd.).

Soil analysis

Soil mineral nutrient analysis was performed on the soil prior to biochar applications. Soil pH was measured in 1:2 (w/v) deionized water. Mineral N was extracted with 2N KCl and quantified colorimetrically using a continuous flow autoanalyzer (Bran and Luebbe Autoanalyzer, SPX, Charlotte, NC, USA). Phosphorus was determined using the Olson-P extraction (Kuo 1996). Exchangeable nutrients were determined by Mehlich-3 extraction (Mehlich 1984). Cation exchange capacity was determined by ammonium acetate extraction buffered at pH 7 (Sumner et al. 1996). All extracts were analyzed by ICP.

The pH of all of the biochars was determined in 1:20 dionized water (w/v). Biochar subsamples (1.0 ± 0.01 g) were weighed directly into 60-mL screw-top glass vials. Vials were filled with 20 mL of 1 M KCl prepared with deionized water and then agitated on an orbital shaker table for 1.5 h. The slurry was mixed continuously with a stir bar while pH was measured. All analyses were performed in duplicate.

Rhizobium growth with acetone-soluble biochar extracts

The volatile material was extracted from the untreated biochars used in Experiment 1 with acetone. Thirty three grams of each of the seven biochars were placed into 1-L Nalgene™ (Thermo Fisher Scientific) wide-mouth screw-top bottles. To these bottles 330 mL of acetone was added. The bottles were then shaken overnight. After shaking, the biochar/acetone mixture was filtered through Adventec® GC-50 filter discs (Toyo Roshi Kaisha, Ltd. Tokyo, Japan) placed in a ceramic Buchner funnel inserted in a 500-mL glass vacuum flask (Corning Glass, Corning, NY, USA). The acetone extracts in the glass vacuum flasks were then placed on an 80˚C sand bath and evaporated until the total volume was just below 50 mL. Once the volume of each of the acetone extracts was below 50 mL they were quantitatively transferred into 50-mL Falcon™ conical polypropylene centrifuge tubes (Thermo Fisher Scientific) and returned to the sand bath until just before reaching total dryness. The extracts were suspended in 10 mL of sterile deionized water by vortexing small aliquots for 10 minutes on a mini vortexer M7 (Randnor, PA, USA). The emulsions, including an acetone/water control, were then poured over 100 mm x 30 mm yeast extract mannitol agar medium (in 4 replicates). The plates were left inside a laminar flow hood with the lids off until all of the liquid had evaporated or imbibed. The plates were then left to rest for one day before 100 µL of *Rhizobium tropici* (strain CIAT 899) were plated. Pure cultures of CIAT 899 in yeast extract mannitol broth were cultured overnight at 30˚C on an orbital shaker to turbidity. The cultures were then diluted to 10^{-6} and 10^{-7} with sterile de-ionized water and plated using the drop-plate method (Somasegaran et al. 1985). The plates were then incubated at 22˚C for three days (no more colonies appeared with additional incubation time). The colony forming units were then counted under a dissecting microscope.

Mycorrhizae colonization

In Experiment 2, 1 g of plant roots was taken from each plant at harvest, rinsed in deionized water and stained following the protocol described by Koske and Gemma (1989). One gram of washed bean roots was placed into labeled 50-mL Falcon™ conical polypropylene centrifuge tubes (Thermo Fisher Scientific). To these tubes 35 mL of 10% KOH solution was added. Tubes were then placed in a 90˚C water bath for 15 minutes to clarify the roots. Roots in each tube were then washed with two rinses of 40 mL deionized water. Then 40 mL of 1% HCl was added to each tube. The tubes were then capped and allowed to sit overnight. The following day the HCl solution was decanted and 40 mL of a trypan blue staining solution was added to each tube. The tubes were then placed in a 90˚C water bath for 15 minutes. The stain was then decanted and the roots were rinsed with 40 mL of 1% HCl before a final 40 mL of an acidified glycerol de-staining solution was added. The roots were transported from Kenya to Cornell University in the de-staining solution for further analysis.

After de-staining four randomly selected 15-mm root fragments were removed and mounted in glycerol on glass microscope slides (VWR International, LLC. Radnor, PA, USA). Once mounted root mycrorrhizae colonization was scored using the gridline intersect method at 400X on a compound microscope (Brundrett et al. 1996).

Statistical analyses

All statistical analyses were performed with JMP software (SAS, Cary, NC). All procedures were performed at $P<0.05$, unless otherwise indicated. Significant treatment effects were determined using the Tukey's HSD test.

Results

Greenhouse Experiment 1

Plant and nodule biomass

Shoot, root, and nodule biomass increased significantly in response to all biochar amendments relative to the unamended control (Table 1.2; Supplementary Table 1.S4 for individual means). Shoot biomass increased between 263 and 293%, root biomass increased between 134 and 178%, and nodule biomass increased between 2953 and 4927% relative to the unamended control for the averaged values according to the main effects (Table 1.2). Choice of feedstock used to produce the biochar significantly influenced plant and nodule biomass (Table 1.2). However, shoot biomass only varied with additions of biochar made from different feedstocks, not as a result of treatment of biochars post production or with different pyrolysis temperatures. In addition, extracting biochars with acetone caused a significant increase in nodule biomass above the other biochar treatments.

Table 1.2. Bean shoot, root, and nodule biomass responses to biochar feedstock, pyrolysis temperature, and post-pyrolysis treatment. Different letters indicate significant differences. Linear contrast between all biochar and the control (Feedstock:Tukey's HSD, $P<0.05$, $n=32$ within biochar; Temperature Tukey's HSD, $P<0.05$, $n=112$; Post-pyrolysis treatment Tukey's HSD, $P<0.05$, $n=56$). Letters are not shown when differences are not significant.

Feedstock	Shoot biomass (g pot^{-1})	Root biomass (g pot^{-1})	Nodule biomass (g pot^{-1})
Rice	2.06 ± 0.10 a	0.50 ± 0.03 a	0.157 ± 0.011 ab
Bagasse	1.85 ±0.10 a	0.48 ± 0.02 ab	0.147 ± 0.011 ab
Maize stover	1.66 ± 0.11 a	0.50 ± 0.03 a	0.117 ± 0.012 b
Maize cobs	1.67 ± 0.11 a	0.43 ± 0.03 ab	0.119 ± 0.012 ab
Eucalyptus	1.83 ± 0.10 a	0.38 ± 0.03 b	0.115 ± 0.012 b
Delonix	2.05 ± 0.10 a	0.49 ± 0.03 ab	0.171 ± 0.012 a
Tea	1.90 ± 0.10 a	0.41 ± 0.03 ab	0.168 ± 0.012 a
Control	0.71 ± 0.32 b	0.28 ± 0.08 c	0.004 ± 0.037 c
P-value	0.0327	0.0056	0.0006
Temperature			
350	1.88 ± 0.06	0.48 ± 0.01 a	0.14 ± 0.01
550	1.84 ± 0.06	0.43 ± 0.01 b	0.14 ± 0.01
P-value	0.5536	0.0387	0.6591
Treatment			
None	1.87 ± 0.8	0.42 ± 0.02	0.14 ± 0.01 b
Acetone	1.99 ± 0.08	0.46 ± 0.02	0.17 ± 0.01 a
H_2O	1.81 ± 0.08	0.47 ± 0.02	0.15 ± 0.01 b
HCl	1.76 ± 0.08	0.48 ± 0.02	0.11 ± 0.01 b
P-value	0.1859	0.2037	<0.0001

Nodule number and nitrogen derived from fixation

Nodule number and Ndfa increased significantly in response to all biochar additions (Table 1.3). When measured in total amounts (mg plant^{-1}), biochar additions increased Ndfa between 1530 and 3022% above the unamended control. When expressed as a proportion of total N, biochar applications increased Ndfa

Table 1.3. Bean nitrogen derived from fixation and nodule counts in response to biochar feedstock, pyrolysis temperature and post-pyrolysis treatment. Different letters indicate significant differences. Linear contrast between all biochar and the control (Feedstock: Tukey's HSD, P<0.05, n=32 within biochar; Temperature: Tukey's HSD, P<0.05, n=112; Treatment: Tukey's HSD, P<0.05, n=56). Letters are not shown when differences are not significant.

Feedstock	Ndfa (mg N plant^{-1})	Ndfa (% total N)	Root nodules (number pot^{-1})
Rice	34.00 ± 2.68 a	45.47 ± 2.81 a	145 ± 11 ab
Bagasse	25.55 ± 2.64 ab	40.57 ± 2.77 a	141 ± 11 ab
Maize stover	19.89 ± 2.93 b	34.68 ± 3.07 a	122 ± 12 b
Maize cobs	17.21 ± 2.88 b	35.06 ± 3.01 a	107 ± 12 b
Eucalyptus	18.71 ± 2.77 b	33.43 ± 2.91 a	146 ± 11 ab
Delonix	24.09 ± 2.82 ab	35.14 ± 2.96 a	179 ± 11 a
Tea	25.58 ± 2.77 ab	43.20 ± 2.91 a	186 ± 11 a
Control	1.25 ± 8.63 c	3.14 ± 2.77 b	22 ± 35 c
P-value	0.0005	0.0145	<0.0001
Temperature			
350	21.00 ± 1.53 b	34.12 ± 1.53 b	137 ± 6 b
550	26.76 ± 1.56 a	42.91 ± 1.56 a	157 ± 6 a
P-value	0.0090	<0.0001	0.0260
Treatment			
None	25.82 ± 1.98 b	40.37 ± 1.93 b	136 ± 9 b
Acetone	33.27 ± 1.94 a	49.79 ± 1.89 a	178 ± 9 a
H_2O	21.72 ± 2.04 b	36.63 ± 2.00 b	144 ± 9 b
HCl	13.79 ± 2.00 c	26.13 ± 1.95 c	130 ± 9 b
P-value	<0.0001	<0.0001	0.0006

between 1066 and 1450% above the unamended control. The proportion of Ndfa did not vary between plants after additions of biochars made from different feedstocks. In contrast, total amounts of Ndfa were on average 83% greater with rice hull biochar than biochar obtained from Eucalyptus, maize cobs, or maize stover. Nodule number was, on average, 55% greater with tea and *Delonex* biochar than with biochar produced from maize cobs or maize stover.

Pyrolysis temperature had a lesser effect on Ndfa than biochar feedstock. Additions of biochar produced at 550°C only resulted in 15% greater Ndfa amount per pot and 25% greater Ndfa proportion in plants than those produced at 350°C (Table 1.3). The number of root nodules was 15% greater with additions of biochar produced at 550˚C than of biochar produced at 350˚C.

Post-pyrolysis extraction with acetone resulted in significantly increased Ndfa (41-29% amount of Ndfa, 23-86% proportion of Ndfa) and nodule number (32-37%) relative to the other three treatments (Table 1.3). Steam treatment of biochar did not significantly change Ndfa. However, acid extraction of biochars significantly decreased Ndfa. In contrast, the number of root nodules did not differ after additions of untreated, steam treated or acid-treated biochar.

Plant nutrient uptake

Plant nutrient concentration and total uptake was significantly affected by biochar feedstock for all measured plant nutrients (Table 1.4). Increases in plant tissue nutrient concentrations and nutrient uptake after biochar additions in comparison to the control were, 109 and 466% for P, 0 and 221% for K, 16 and 229% for Ca, 15 and 240% for Mg, and 13 and 194% for Mn, respectively. Phosphorus, Ca, and Mn uptake varied significantly with pyrolysis temperature, where plant P uptake and tissue concentrations were 22 and 18% higher, respectively, in soils amended with biochar produced at 550°C than at 350°C (Table 4). In contrast, Ca concentration and uptake were 14 and 11% greater, and Mn concentration and uptake were 14 and 19% higher with biochars made at 350°C than 550°C, respectively. Post-pyrolysis modification of biochars did not result in large and consistent differences in foliar nutrient concentrations, except for P, Ca and Mn.

Table 1.4. Bean plant nutrient content and uptake following applications of biochar prepared from various feedstocks, production temperatures, and post-pyrolysis treatments. Different letters indicate significant differences (Feedstock: Tukey's HSD, $P<0.05$, $n=32$ within biochar; linear contrast between all biochar and the unamended control, $P<0.05$ $n=3$; Temperature: Tukey's HSD; $p<0.05$; $n=112$; Treatment: Tukey's HSD, $P<0.05$, $n=56$). Letters are not shown when differences are not significant.

	P	K	Ca	Mg	Mn	Na	P	K	Ca	Mg	Mn	Na
	Concentration (mg g^{-1})						Uptake (mg pot^{-1})					
Feedstock												
Rice	1.78c	30.25a	19.68b	1.87c	0.13b	0.12a	3.57c	62.12a	40.06b	3.77d	0.25b	0.24a
Bagasse	3.85a	15.11c	28.31a	0.63d	0.26b	0.02de	7.08ab	27.04d	51.72a	1.00e	0.49a	0.03cd
Maize stover	3.46ab	30.15a	19.40b	3.00ab	0.27b	0.01e	5.74b	49.91bc	31.78bc	4.88bc	0.44a	0.02d
Maize cobs	3.27b	30.77a	20.53b	2.89ab	0.22b	0.06b	5.68b	53.89abc	34.81bc	5.13bc	0.38ab	0.10b
Eucalyptus	3.18b	24.20b	19.43b	2.66b	0.20ab	0.04bcd	5.81b	43.75c	35.75bc	4.90bc	0.37ab	0.07b
Delonix	3.62ab	28.41a	19.81b	3.32a	0.25b	0.04bc	7.64a	56.03ab	40.44b	6.49a	0.50a	0.08b
Tea	3.87a	19.27a	19.41b	3.04ab	0.22b	0.03cde	7.13ab	52.91abc	35.73bc	5.45b	0.41a	0.07bc
Control	1.85d	34.38a	24.26ab	2.83ab	0.23b	0.03bcde	1.35c	36.62bcd	15.73c	2.96cde	0.17c	0.02bcd
Feedstock effect[a]	***	***	***	***	***	***	***	***	***	***	***	***
Temperature												
350	2.94b	27.55	21.75	2.45	0.24b	0.05	5.58b	52.34a	40.98a	4.67	0.44a	0.09
550	3.60a	26.05	20.22	2.50	0.21a	0.04	6.58a	46.18b	36.93b	4.33	0.37b	0.08
Temperature effect[a]	**	*ns*	*ns*	*ns*	*	*ns*	**	**	*	*ns*	*	*ns*
Treatment												
None	3.52	27.65	19.27b	2.42ab	0.21b	0.05	6.56ab	53.42	35.52b	4.70	0.39b	0.09
Acetone	3.34	25.54	18.52b	2.33b	0.18b	0.04	6.70a	46.49	37.25b	4.13	0.35b	0.08
HCl	3.05	27.00	26.21a	2.79a	0.32a	0.05	5.28b	48.64	45.73a	4.93	0.55a	0.09
Steam	3.17	27.00	19.43b	2.38ab	0.17b	0.04	5.71ab	48.57	35.79b	4.26	0.32b	0.09
Treatment effect[a]	*ns*	*ns*	***	**	***	*ns*	*	*ns*	***	*ns*	***	*ns*

[a] main effect of all treatments; *, **, ***, and ns significant at $P<0.05$, 0.01, 0.001, and not significant, respectively

In the principal component analysis, Ndfa, the number of root nodules, and nodule biomass were most closely correlated with plant tissue P and P uptake (Figure 1.1). These metrics were to a lesser extent related to Ca and P in the biochar, biochar pH, and unrelated to plant tissue Mn and Ca contents.

Acetone-soluble biochar compounds and rhizobial growth plates

All of the YMA plates treated with acetone-soluble biochar residues from biochar produced at 350˚C resulted in no observable rhizobial growth, but rhizobia counts were not different from the control on YMA containing acetone extracts from biochar produced at 550˚C (Table 1.5; except for plates containing extracts from maize stover). Using a linear contrast, rhizobial growth was 19 and 20% greater on plates treated with acetone-soluble VM extracts from biochars produced from Delonix (P = 0.0347) and rice hulls (P = 0.0447) at 550˚C, respectively, than the acetone-residue control. Acetone did not adversely affect the rhizobia, as growth on plates with acetone-residue did not differ from growth on untreated YMA plates.

Greenhouse Experiment 2

Shoot biomass was significantly greater when inorganic fertilizer was added than when biochar was added. Shoot biomass after biochar application was not significantly different from the unamended control (Table 1.6). In contrast, nodule biomass and number were significantly greater (from 6 to 35 times) when untreated biochar was added than either the fertilizer or control treatments (Table 1.6). No Ndfa

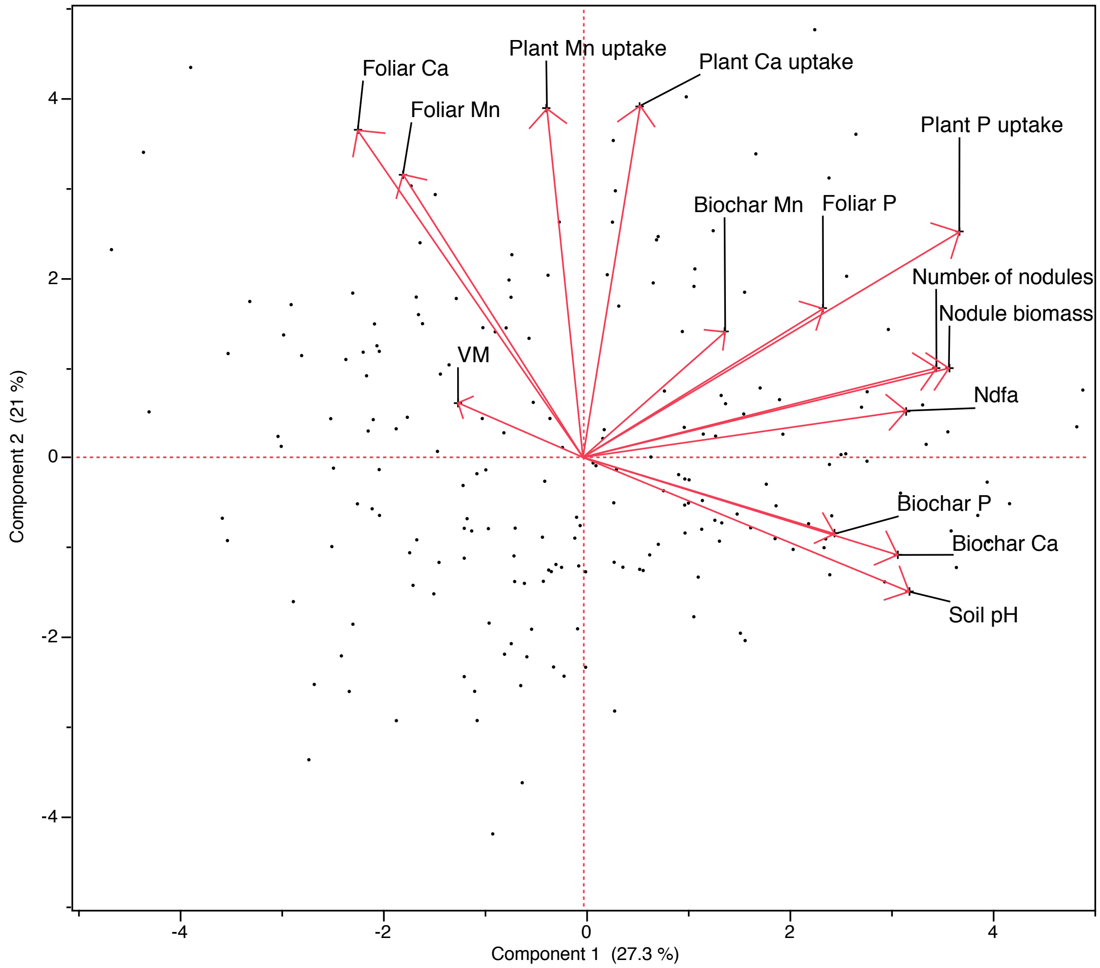

Figure 1.1. Principal component analysis correlation biplot depicting the relationship between plant and microbial response variables and selected biochar chemical properties. Eigenvalues for the first two components are 3.82 and 2.94 and represent 27 and 21% of the variability, respectively. Seventy four percent of the variability were contained in the first four components (see Table S6 for component loading values). Foliar nutrient contents are concentrations in the bean tissue, plant uptake are total nutrient uptake per pot, biochar nutrients are concentrations, and Ndfa is N derived from biological N fixation (mg pot^{-1}).

was measured with inorganic fertilizer additions. Little Ndfa was measured (0.81 mg N pot^{-1}, 1% of N) in the unammended control without any additions. Ndfa was between 4.5-9.0 mg N pot^{-1} (8-18% of N) with biochar additions (Table 1.6). Arbuscular mycorrhizal colonization in the plant roots grown in soil with the

Table 1.5. Rhizobium colony forming units cultured on yeast mannitol agar (YMA) plates incorporated with acetone-soluble biochar extracts. Values followed by the same letter are not significantly different, Tukey's HSD, P<0.05, n=4, control and acetone/water control n=8.

Feedstock	Temperature	Colonies plate^{-1}
Rice	350	0.00 ± 0.00 d
	550	$2.88x10^7 \pm 0.3x10^7$ a
Bagasse	350	0.00 ± 0.00 d
	550	$1.70x10^7 \pm 0.20x10^7$ bc
Maize stover	350	0.00 ± 0.00 d
	550	0.00 ± 0.00 d
Maize cobs	350	0.00 ± 0.00 d
	550	$2.20x10^7 \pm 0.10x10^7$ abc
Eucalyptus	350	0.00 ± 0.00 d
	550	$2.72x10^7 \pm 0.40x10^7$ a
Delonix	350	0.00 ± 0.00 d
	550	$2.90x10^7 \pm 0.07x10^7$ a
Tea	350	0.00 ± 0.00 d
	550	$2.20x10^7 \pm 0.07x10^7$ abc
Control (YMA only)		$2.41x10^7 \pm 0.19x10^7$ ab
Control (YMA and acetone-extract residue)		$1.65x10^7 \pm 0.20x10^7$ c
P-value	-	<0.0001

unmodified biochars was 65-71% and 140-149% greater than the no biochar fertilizer and no fertilizer control treatments, respectively.

Extracting nutrients from biochars decreased their ability to enhance Ndfa by 30-49% (Table 1.6; compared to the no biochar and fertilizer control). However, the pH of the biochar did not appear to play any role, as Ndfa was unchanged whether biochars had a pH of 4-5 or 8-11. Without extracting nutrients, all biochar additions significantly increased mycorrhizal colonization by 71-154% compared to no nutrient additions. Similar to Ndfa, mycorrhizal colonization was not affected by biochar pH. Adding fertilizer without biochar did not affect root mycorrhizae colonization.

Table 1.6. Bean shoot and nodule biomass, nitrogen derived from fixation, nodule counts, and mycorrhizae root colonization in response to biochar and nutrient additions (nutrient additions equivalent to those in Delonix biochar). Different letters indicate significant differences. Tukey's HSD, $P<0.05$, $n=5$. Letters are not shown when differences are not significant. Comparisons only valid within columns between capitalized or non-capitalized letters pH in 1:10 (w/v) H_2O.

	Number of nodules (pot^{-1})	Nodule biomass (mg pot^{-1})	Shoot biomass (g pot^{-1})	Ndfa (mg N pot^{-1})	Ndfa (% total N)	Mycorrhizae (% root colonization)
Unextracted biochar						
Delonix (pH 10.43)	59.80 ± 8.11 A	47.66 ± 7.98 A	1.78 ± 0.15 B	8.93 ± 1.49 A	17.48 ± 2.11 A	86.86 ± 6.66 A
Eucalyptus (pH 8.27)	42.80 ± 8.11 A	30.35 ± 7.98 AB	2.02 ± 0.15 B	4.48 ± 1.33 AB	7.46 ± 1.89 B	89.91 ± 6.66 A
Extracted biochar						
Delonix (pH 10.47)	37.20 ± 7.17 ab	17.18 ± 3.64 ab	1.84 ± 0.13 bc	3.64 ± 0.85 a	7.51 ± 1.55 ab	91.89 ± 6.94 a
Delonix (pH 4.37)	44.00 ± 8.01 a	20.34 ± 4.06 a	1.53 ± 0.15 bc	4.34 ± 0.85 a	8.97 ± 1.55 a	78.36 ± 6.94 ab
Eucalyptus (pH 8.35)	32.80 ± 7.17 ab	15.28 ± 3.64 ab	1.86 ± 0.13 b	2.15 ± 0.85 ab	4.00 ± 1.55 abc	61.81 ± 6.94 ab
Eucalyptus (pH 4.99)	2.00 ± 9.25 b	0.91 ± 4.69 ab	1.17 ± 0.17 c	1.32 ± 0.85 ab	2.96 ± 2.01 abc	64.00 ± 7.76 ab
No biochar						
With nutrient additions	42.75 ± 8.01 AB(a)	5.26 ± 4.06 B(ab)	2.71 ± 0.15 A(a)	0.00 ± 0.85 C(b)	0.00 ± 1.55 C(c)	52.49 ± 6.94 B(bc)
Without nutrient additions	8.40 ± 7.17 B(b)	1.36 ± 3.64 B(b)	1.72 ± 0.13 B(bc)	0.81 ± 0.85 BC(ab)	1.13 ± 1.55 BC(bc)	25.37 ± 8.96 B(c)
P-value						

Discussion

Biochar effects on plant growth and nitrogen fixation

The significant increases in plant growth with any of the biochars mirror similar increases for experiments with highly weathered soils (Major et al. 2008; Steiner et al. 2007; Van Zwieten et al., 2010) and exceed the increases in nitrogen fixation reported by Rondon et al. (2007). Several indications exist that P was the nutrient most strongly limiting plant growth in the studied soil. Only foliar P concentrations increased with biochar additions and with greater pyrolysis temperature typically leading to greater nutrient contents in the biochar observed due to C, H and O losses (Enders et al. 2012). Foliar Ca and Mn concentrations and uptake increased as a result of the addition of biochar from which nutrients had been extracted despite a significant reduction in its Ca content, in contrast to other nutrients. Despite pH adjustment after the acid extraction procedure, the biochar was found to have a substantially lower pH than those of the other post-pyrolysis treatments. Hollister et al. (2013) identified Ca species to be present in calcite form in biochar produced at 550˚C; it is possible that any remaining Ca in the biochar could have been dissolved from otherwise unavailable carbonates in the ash, which may not have been available to the plants at the native biochar pH, and Mn availability increased by lower pH. We hypothesized that the additions of plant limiting nutrients found in the biochar would increase plant growth, nodulation and BNF. While plant mineral nutrient uptake, and in the case of P also its foliar concentrations, significantly increased with biochar additions, the increase in plant mineral nutrition could not be directly related to mineral nutrient additions from the biochar. When mineral nutrients were applied to the soil at the highest rate found in the biochar additions, plant growth increased to the response measured with biochar additions, but BNF did not increase. This indicates that mineral nutrients were indeed limiting in the studied soil and the alleviation of nutrient deficiencies improved plant growth. Conversely, when mineral nutrients were extracted from biochars, increases in N fixation with biochar additions did not disappear. These different lines of evidence suggest that biochar is altering the soil environment to enable increased nutrient uptake not merely related to nutrient additions from the biochar alone.

Reasons for increased nitrogen fixation with biochar

Mycorrhizal colonization and phosphorus nutrition

Improved P nutrition of the plants was the most likely explanation for greater Ndfa in response to biochar additions, albeit unrelated to the biochar P contents. One potential mechanism for greater P uptake found in the plants may be an improved access to soil P through the observed increase in mycorrhizal colonization. Mycorrhizae have a well-established connection to improved plant nutrient uptake, with particular relevance to P nutrition (Vance et al. 2000; Vance 2001), and several studies have documented greater mycorrhizal colonization after biochar additions to soil where P or other soil resources are limiting (Solaiman et al. 2010; Rillig et al. 2010). In our study, it remained unclear what the mechanism was for the greater mycorrhizal colonization with biochar additions. Several mechanisms have been hypothesized for the promotion of mycorrhizae with biochar (Lehmann et al. 2011; Warnock et al. 2007), such as an improvement of soil nutrient availability for mycorrhizae though our data do not support this hypothesis. Mycorrhizal colonization was not significantly different between unaltered biochar and biochar that had been leached of mineral nutrients. We also did not find significant differences between high or low pH biochars. Other proposed mechanisms include a shift in communities of other microorganisms that influence mycorrhizae (e.g. Mycorrhization Helper Bacteria) and biochar as a possible refuge for colonizing fungi. However, the design of our experiment did not test these hypotheses.

Amelioration of soil pH

Previous studies have documented the potential of biochar to ameliorate soil acidity and improve nutrient availability (Novak et al. 2009; Van Zwieten et al. 2010; Yuan and Xu 2011). While the biochar additions in our study significantly increased soil pH (albeit only by 0.3-0.4 pH units), biochar pH was not correlated with the plant or microbial responses. In addition, some of the greatest plant and BNF responses were found from additions of acidic acid-treated biochar with a pH below the native soil pH. However, changes in pH resulting from biochar additions at the rhizosphere-scale, undetectable by our bulk soil observations, could have improved nutrient availability locally. This could not be empirically ruled out in this study and may have partially contributed to the increases in plant and microbial responses.

Influence of volatile matter on rhizobial growth

The second hypothesis we tested was that the acetone-soluble compounds in biochar may stimulate rhizobial symbiosis. Our data did not support this hypothesis across all biochars. On the contrary, when the biochars were leached with acetone to attempt to reduce the volatile matter, the plant and microbial responses consistently increased over unaltered biochar. This suggests there is an acetone-soluble compound or compounds that were partially inhibitory to nodulation and possibly led to reduced Ndfa. In addition, when the acetone-soluble compounds were removed and tested directly with rhizobium on growth plates this resulted in failure of bacterial growth on YMA plates treated with the acetone extracts from the biochar manufactured at the lower pyrolysis temperature (350˚C). This is direct evidence for the toxicity of some acetone-soluble volatile matter on rhizobium at the concentrations used in this experiment. In contrast, acetone-soluble extracts from biochar manufactured at the higher temperature (550˚C) did not have negative effects on rhizobial growth except from maize stover biochar. As the total VM defined by the ASTM method was greater in the biochar manufactured at the lower temperature than in the biochar manufactured at the higher temperature, it is possible that the toxicity of the acetone-soluble material was due to quantitative rather than qualitative differences. The greater rhizobial growth with the high-temperature Delonix and rice biochars demonstrate that some VM fractions may have a stimulatory effect on rhizobium.

Greater nodule number and Ndfa seen in response to increasing pyrolysis temperature corroborated plant growth differences seen in other studies. Rajkovich et al. (2012) found maize growth increased as pyrolysis temperatures increased from 300°C to 600°C, but the authors could not correlate the changes in maize growth with VM or plant N uptake. In our study, biochar produced at 550°C had lower total VM contents than biochar produced at 350°C. In previous studies VM has been correlated to reduced plant responses (Deenik et al. 2011) and microbial toxicity (Painter 1998). Some of the compounds isolated from VM are known to be phytotoxic (Fernandes and Brooks 2003; Fernandes et al. 2003). Others have reported compounds beneficial to plant germination in wood smoke (Light et al. 2009) or have hypothesized that there are chemicals in biochar that may stimulate plant growth at low doses (Graber et al. 2010). While our data supports the toxicity of some acetone-soluble VM from biochar, it cannot be concluded that the entire spectrum of VM in biochar was toxic to rhizobium. On the contrary, the acetone-soluble extracts from some of the biochars improved rhizobial growth. It is not known whether this stimulatory effect was from specific growth inducing compounds or from the presence of greater metabolizable C compounds.

While the acetone wash did not significantly reduce the total volatile content of the biochar as measured by the ASTM method, Deenik et al. (2011) extracted and identified phytotoxic compounds from biochar using acetone. These compounds reduced plant growth and N uptake and are known to be phytotoxic. The ASTM method appears not to be sensitive enough to measure subtle biologically important changes in VM quantity or composition. However, the data suggest that the majority of the ASTM-defined VM has low solubility or is not soluble in acetone, and our conclusions about the effect of VM are restricted to the VM fraction that is extractable by acetone. It is also possible that the VM in the low-temperature biochars used in this experiment were toxic due to the concentrations present. It has been hypothesized that the VM in biochar might follow a hormetic response where the response is dependent on application rates; at low concentrations it may be beneficial and toxic at high concentrations (Graber et al. 2010). However, this hypothesis was not directly tested in this experiment. What is also not known is the biological activity of the VM remaining in the biochar after the acetone extraction.

Conclusion

Our results clearly demonstrated that biochar has the potential to significantly improve BNF and bean growth in the studied highly degraded and P-deficient soil. Mineral nutrient addition and soil acidity amelioration with biochar are only to a small extent responsible for the increased responses observed. Increased plant P uptake was most closely related to improved BNF which may be a result of the observed increases in arbuscular mycorrhizal colonization and not related to nutrient additions. Further work should be done investigating the mechanisms for greater arbscular mycorrhizal colonization and verifying if the improved plant nutrition, and specifically P uptake, was indeed nutrient uptake facilitated by mycorrhiza. More investigations are also required to partition the effects of the VM from the rest of the components of biochar. Biochar VM likely is highly heterogeneous and it is possible that other components of this material that are not extractable by acetone might be beneficial or detrimental to rhizobium. Field trials are also needed to determine the full potential of amending soil with biochar to BNF and bean yields.

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APPENDIX

Table 1.S1. Properties of biochar produced from seven feedstocks, at two pyrolysis temperatures with four post-pyrolysis treatment.

Feedstock	Temp	Treat	C (%)	Organic C (%)	N (%)	O (%)	H (%)	Volatile matter (%)	Ash (%)	Fixed C (%)	Volatile matter-ash free (%)	Fixed C-ash free (%)	C:N	H:C	O:C	H:Corg	O:Corg
Rice	350	None	41.31	56.71	0.50	15.18	2.52	24.10	40.49	35.42	31.02	68.98	81.91	0.65	0.16	0.79	0.20
		Acetone	40.02	43.17	0.40	17.95	2.52	24.81	39.11	36.08	33.35	66.65	100.60	0.72	0.22	1.02	0.31
		HCl	40.48	40.66	0.45	18.28	2.67	25.55	38.12	36.33	37.25	62.75	89.92	0.66	0.19	1.93	0.56
		Steam	40.39	38.36	0.48	16.00	1.11	21.60	42.02	36.38	41.29	58.71	83.31	0.62	0.18	1.01	0.28
	550	None	42.00	39.44	0.52	5.42	3.30	8.51	48.75	42.74	13.71	86.29	80.65	0.32	0.05	0.70	0.10
		Acetone	42.61	29.07	0.36	8.77	1.27	8.30	46.99	44.71	14.75	85.25	119.68	0.32	0.08	0.91	0.23
		HCl	39.05	26.49	0.37	11.00	1.48	7.93	48.09	43.98	12.54	87.46	105.21	0.33	0.09	1.10	0.31
		Steam	41.38	13.94	0.31	5.58	1.38	7.30	51.36	41.34	13.94	86.06	133.57	0.34	0.05	2.02	0.30
Bagasse	350	None	56.56	53.02	0.33	11.73	3.01	26.54	28.38	45.07	36.31	63.69	172.88	0.63	0.16	0.67	0.17
		Acetone	54.74	33.45	0.30	16.64	2.61	26.56	25.71	47.73	35.75	64.25	180.99	0.73	0.30	0.42	0.18
		HCl	50.03	43.84	0.29	18.04	3.20	24.34	28.44	47.22	39.06	60.94	170.99	0.33	0.34	0.54	0.56
		Steam	62.53	49.92	0.34	6.70	2.08	27.98	28.35	43.67	34.02	65.98	184.37	0.78	0.12	1.11	0.18
	550	None	62.64	30.17	0.25	7.53	1.96	10.51	27.62	51.74	16.76	83.24	250.19	0.30	0.08	0.67	0.19
		Acetone	68.53	45.08	0.21	2.65	1.71	12.57	26.91	60.53	17.19	82.81	328.35	0.45	0.05	0.27	0.03
		HCl	70.60	41.84	0.26	2.44	1.69	11.09	25.01	63.90	13.91	86.09	269.81	0.36	0.04	0.25	0.03
		Steam	61.33	61.08	0.27	13.02	1.52	10.59	23.87	65.54	14.79	85.21	230.60	0.94	0.23	0.55	0.14
Maize stover	350	None	67.14	43.84	0.78	14.02	3.51	31.03	14.55	54.42	40.49	59.51	85.53	0.65	0.16	0.99	0.24
		Acetone	57.26	33.17	0.72	24.95	3.85	32.53	13.22	54.25	37.49	62.51	80.02	0.57	0.34	0.93	0.56
		HCl	62.92	24.48	0.65	17.55	3.58	34.97	15.31	49.73	36.43	63.57	97.54	0.76	0.26	0.87	0.30
		Steam	57.52	42.17	0.71	26.57	3.63	32.21	11.58	56.21	41.29	58.71	81.28	0.40	0.32	0.49	0.40
	550	None	67.73	45.99	0.51	14.00	1.94	14.11	15.83	70.06	16.60	83.40	133.94	0.29	0.13	0.52	0.23
		Acetone	68.54	70.77	1.02	14.35	3.32	13.61	12.78	73.61	15.61	84.39	67.45	0.37	0.17	0.52	0.24
		HCl	71.19	45.11	0.40	17.63	1.85	13.80	8.93	77.27	13.39	86.61	179.85	0.28	0.19	0.48	0.32
		Steam	78.97	46.53	0.58	6.37	3.86	12.02	10.22	77.76	15.15	84.85	136.26	0.29	0.08	0.30	0.08
Maize cobs	350	None	71.37	49.99	0.80	18.61	3.97	29.39	5.25	65.36	37.06	62.94	89.42	0.75	0.35	0.60	0.28
		Acetone	68.36	70.77	0.76	22.48	3.58	31.74	4.82	63.44	33.35	66.65	90.13	0.72	0.27	1.02	0.39
		HCl	66.09	24.26	0.73	26.53	3.64	32.85	3.01	64.14	30.72	69.28	90.01	0.68	0.30	1.12	0.49
		Steam	71.53	28.49	0.82	17.52	3.60	28.71	6.53	64.76	33.87	66.13	86.77	0.66	0.19	1.17	0.34
	550	None	82.90	46.91	0.43	6.95	2.04	12.66	7.69	79.66	16.89	83.11	194.13	0.40	0.13	0.35	0.11
		Acetone	80.92	65.33	0.43	12.11	2.18	14.10	4.35	81.55	14.75	85.25	186.26	0.32	0.11	0.91	0.31
		HCl	82.64	59.62	0.44	12.83	2.02	13.65	2.07	84.28	12.54	87.46	188.92	0.33	0.11	1.10	0.36
		Steam	81.73	70.78	0.50	10.16	1.95	11.83	5.66	82.51	13.94	86.06	164.16	0.34	0.09	2.02	0.55
Eucalyptus	350	None	67.08	44.09	0.23	27.12	3.84	35.08	1.72	63.19	35.70	64.30	287.75	0.64	0.31	0.94	0.46
		Acetone	67.86	66.10	0.19	26.50	3.76	36.39	1.69	61.93	37.01	62.99	353.03	0.60	0.28	0.64	0.30
		HCl	69.08	40.07	0.21	25.98	3.79	35.22	0.94	63.84	35.34	64.66	332.04	0.58	0.26	1.08	0.49
		Steam	61.59	48.82	0.22	32.26	3.71	34.55	2.22	63.22	35.56	64.44	282.87	0.53	0.33	0.81	0.50
	550	None	83.18	54.10	0.19	10.81	2.37	12.24	3.45	84.31	12.67	87.33	438.84	0.31	0.11	0.43	0.15
		Acetone	86.58	33.52	0.17	8.61	2.32	12.92	2.32	84.76	13.23	86.77	521.94	0.33	0.08	0.77	0.19
		HCl	81.25	53.38	0.17	14.81	2.22	13.25	1.56	85.19	11.80	88.20	466.38	0.30	0.15	0.43	0.21
		Steam	87.67	78.66	0.13	7.32	2.45	11.51	2.43	86.06	13.46	86.54	681.32	0.27	0.07	0.26	0.07
Delonix	350	None	69.89	72.68	1.93	18.19	3.53	31.61	6.46	61.94	33.79	66.21	36.26	0.60	0.20	0.56	0.19
		Acetone	65.12	81.08	1.95	22.53	3.49	32.13	6.91	60.95	34.52	65.48	33.42	0.36	0.26	0.29	0.21
		HCl	75.08	80.04	2.01	16.51	3.64	33.18	2.76	64.05	33.87	66.13	37.43	0.61	0.17	0.54	0.15
		Steam	73.99	63.68	1.93	13.42	3.31	31.39	7.34	61.27	34.13	65.87	38.32	0.30	0.14	0.33	0.16
	550	None	75.41	60.96	1.74	11.81	1.92	11.93	9.13	78.94	13.13	86.87	43.39	0.31	0.12	0.36	0.15
		Acetone	75.46	36.48	1.29	12.42	1.96	14.71	8.86	76.43	16.14	83.86	58.42	0.32	0.11	0.72	0.26
		HCl	77.14	49.51	1.64	16.40	2.17	14.15	2.64	83.20	13.70	86.30	47.00	0.32	0.16	0.50	0.25
		Steam	75.13	53.10	1.29	12.43	1.71	12.40	9.44	78.15	14.54	85.46	58.39	0.34	0.12	0.48	0.18
Tea	350	None	65.19	55.02	1.05	26.26	1.96	31.97	5.53	62.50	33.84	66.16	62.06	0.68	0.31	0.77	0.36
		Acetone	67.38	66.40	0.92	23.56	3.42	33.01	4.72	62.27	34.64	65.36	73.23	0.80	0.31	0.69	0.27
		HCl	70.93	67.59	0.74	24.96	1.78	30.38	1.59	68.03	35.32	64.68	95.35	0.75	0.33	0.64	0.28
		Steam	71.11	61.55	1.00	19.55	3.63	33.66	4.70	61.64	30.87	69.13	70.77	0.62	0.22	0.68	0.24
	550	None	77.78	56.87	0.59	13.47	2.10	10.62	6.06	83.32	11.31	88.69	132.08	0.34	0.15	0.40	0.18
		Acetone	76.62	58.20	0.71	14.23	2.16	12.07	6.28	81.66	12.88	87.12	108.55	0.31	0.15	0.38	0.18
		HCl	81.99	68.76	0.54	13.09	2.20	12.77	2.17	85.06	15.15	84.85	152.46	0.58	0.12	0.67	0.14
		Steam	71.93	75.97	0.91	17.07	1.85	13.90	8.24	77.86	13.05	86.95	78.95	0.58	0.19	0.52	0.17

Table 1.S2. pH and nutrient content of biochar produced from seven feedstocks, at two temperatures, and four post-treatments.

Feedstock	Temperature	Treatment	pH (H_2O)	P (mg g^{-1})	K (mg g^{-1})	Ca (mg g^{-1})	S (mg g^{-1})	Mg (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Cu (mg g^{-1})	Zn (mg g^{-1})	B (mg g^{-1})	Na (mg g^{-1})	Mo (mg g^{-1})
Rice	350	None	8.06	0.46	6.72	1.31	0.20	0.66	0.20	0.27	<det	0.11	0.04	0.43	<det
		Acetone	7.58	0.31	5.93	1.03	0.16	0.43	0.09	0.17	<det	0.08	0.01	0.40	<det
		HCl	8.19	0.03	0.22	0.13	0.09	0.06	0.01	0.01	<det	0.13	<det	2.76	<det
		Steam	8.17	0.75	5.57	1.17	0.27	0.52	0.46	0.24	0.01	0.15	<det	0.80	<det
	550	None	9.95	0.75	4.43	1.09	0.14	0.45	0.27	0.16	<det	0.32	0.01	1.21	<det
		Acetone	9.98	0.58	5.13	1.17	0.14	0.41	0.10	0.10	<det	0.20	<det	0.90	<det
		HCl	5.35	0.22	0.61	0.27	0.08	0.28	0.06	0.10	0.01	0.30	<det	1.15	<det
		Steam	9.47	0.80	4.99	1.28	0.10	0.54	0.10	0.11	<det	0.11	<det	1.06	<det
Bagasse	350	None	7.75	0.60	4.45	1.70	0.26	0.74	9.89	0.74	0.04	0.54	0.01	1.06	<det
		Acetone	6.96	0.63	4.72	2.23	0.26	0.85	10.10	0.75	0.03	0.56	0.01	0.95	<det
		HCl	6.58	0.42	3.24	1.15	0.17	0.62	6.33	0.32	0.03	0.13	0.01	13.28	<det
		Steam	7.15	0.67	4.86	1.89	0.28	0.81	10.27	0.67	0.03	0.19	0.01	0.91	<det
	550	None	9.58	0.78	5.66	2.31	0.27	0.95	12.49	1.21	0.01	0.23	<det	1.77	<det
		Acetone	8.89	0.65	5.15	2.12	0.24	0.90	8.05	0.99	0.02	0.17	<det	1.38	<det
		HCl	5.03	0.52	1.76	1.26	0.14	0.71	4.66	0.35	0.02	0.07	<det	1.24	<det
		Steam	9.94	0.75	5.13	2.16	0.22	0.93	9.42	1.69	0.04	0.17	<det	1.27	<det
Maize stover	350	None	9.25	1.90	25.44	4.84	0.72	2.55	3.02	0.19	0.08	0.09	<det	1.09	<det
		Acetone	8.48	1.78	24.94	3.86	0.74	2.28	1.48	0.12	0.02	0.29	0.01	1.97	<det
		HCl	6.49	0.91	5.45	1.23	0.31	1.11	1.50	0.04	0.01	0.50	<det	10.13	<det
		Steam	9.29	2.70	27.78	4.34	0.84	2.58	3.31	0.17	0.03	0.21	0.01	0.63	<det
	550	None	10.04	3.22	39.70	6.57	0.90	3.29	4.86	0.25	0.06	0.11	0.01	0.45	<det
		Acetone	4.81	2.82	20.17	12.15	0.81	7.54	1.08	0.16	0.06	0.31	<det	0.33	<det
		HCl	10.00	0.80	5.08	4.08	0.37	2.69	0.46	0.09	0.12	0.25	<det	4.74	<det
		Steam	10.03	2.96	14.53	12.05	0.59	5.62	0.26	0.09	0.12	0.06	<det	1.17	<det
Maize cobs	350	None	9.45	1.01	15.17	0.67	0.56	0.66	0.75	0.03	0.01	0.20	0.01	2.52	<det
		Acetone	8.92	1.04	12.71	0.62	0.27	0.57	0.95	0.03	0.01	0.54	0.02	2.74	<det
		HCl	3.34	0.58	3.44	0.48	1.19	0.45	0.55	0.01	0.02	0.06	<det	1.48	<det
		Steam	9.38	1.03	15.31	0.90	0.42	0.80	0.60	0.03	0.01	0.35	0.04	2.75	<det
	550	None	9.67	1.42	21.86	1.26	0.32	1.10	1.48	0.07	0.03	0.31	0.04	1.82	<det
		Acetone	9.44	1.50	23.02	0.87	0.33	0.82	1.70	0.04	0.01	0.27	0.04	2.91	<det
		HCl	2.97	0.86	0.50	0.48	0.11	0.51	0.52	0.00	<det	0.07	0.01	2.29	<det
		Steam	9.64	1.53	20.08	0.75	0.21	0.73	0.48	0.02	0.02	0.13	0.04	3.05	<det
Eucalyptus	350	None	7.52	0.14	0.88	4.72	0.08	1.12	0.00	0.20	0.02	0.14	0.03	1.68	<det
		Acetone	6.67	0.15	2.96	5.38	0.09	1.28	0.04	0.21	0.02	0.02	<det	1.34	<det
		HCl	4.69	0.08	0.08	1.41	0.06	0.82	0.49	0.13	0.01	0.79	0.07	2.15	<det
		Steam	6.98	0.11	1.09	4.49	0.05	1.29	0.42	0.26	0.02	0.25	0.02	1.91	<det
	550	None	9.53	0.21	3.44	6.03	0.09	1.88	0.06	0.36	0.15	0.07	0.03	2.05	<det
		Acetone	9.61	0.24	2.37	6.63	0.08	1.88	0.11	0.36	0.06	0.17	0.02	2.48	<det
		HCl	4.69	0.20	0.13	2.13	0.05	1.52	0.32	0.30	0.11	0.03	<det	2.49	<det
		Steam	10.20	0.34	4.44	6.59	0.07	1.94	0.11	0.40	0.11	0.04	0.01	1.95	<det
Delonix	350	None	8.57	4.93	9.89	9.42	1.78	4.86	0.42	0.04	0.02	0.39	0.01	1.89	<det
		Acetone	8.11	3.71	8.48	8.09	1.46	4.46	0.26	0.01	0.02	0.64	0.02	2.29	<det
		HCl	3.13	1.34	0.78	2.64	0.17	1.30	0.07	0.00	0.01	0.01	<det	3.15	<det
		Steam	8.59	5.69	11.25	11.98	2.31	5.50	1.02	0.03	0.03	1.36	0.02	1.45	<det
	550	None	10.29	6.12	12.93	13.74	2.44	6.67	0.69	0.04	0.11	0.38	0.02	3.06	<det
		Acetone	10.30	6.19	14.05	11.98	2.22	6.44	0.39	0.04	0.05	0.19	0.02	1.95	<det
		HCl	4.09	2.16	0.60	3.33	0.91	2.71	0.21	0.01	0.01	0.19	0.01	1.75	<det
		Steam	10.93	7.05	16.79	21.28	2.69	8.43	0.98	0.06	0.07	0.13	0.04	3.10	<det
Tea	350	None	8.34	1.06	10.20	7.86	0.82	1.62	1.19	1.20	0.03	0.28	0.01	0.84	<det
		Acetone	7.91	0.78	8.83	4.76	0.83	1.14	0.54	0.65	0.04	0.13	0.01	1.07	<det
		HCl	3.49	0.22	5.28	2.76	0.40	1.00	0.15	0.49	0.10	0.00	<det	1.41	<det
		Steam	8.24	1.17	10.28	5.92	0.92	1.32	0.72	0.90	0.02	0.14	<det	0.58	<det
	550	None	9.84	0.28	12.89	6.31	0.72	1.57	0.15	0.87	0.11	0.01	<det	0.77	<det
		Acetone	10.15	1.25	11.63	7.14	0.99	1.58	0.48	1.04	0.11	0.36	0.02	1.22	<det
		HCl	3.55	0.86	0.51	2.76	0.55	1.33	0.14	0.57	0.02	0.29	<det	0.22	<det
		Steam	8.72	1.06	17.52	12.18	0.99	2.43	0.62	1.72	0.05	0.02	<det	0.88	<det

<det represents values below the method detection limit.

Table 1.S3. Soil and biochar pH used in Experiment 2. Biochar pH was measured in 1:10 (w/v) H_2O, soil pH was measures in 1:2 (w/v) H_2O. Values followed by the same letter are not significantly different; feedstock: Tukey's HSD, *P*<0.05, *n*=32 within biochar; linear contrast between all biochar and the control, *P*<0.05 *n*=3; temperature: Tukey's HSD; *P*<0.05; *n*=112; treatment: Tukey's HSD, *P*<0.05, *n*=56. Letters are not shown when differences are not significant.

	Biochar pH	Soil pH
Delonix	10.43	6.18 ± 0.03 ab
Delonix HCl – high pH	10.47	6.39 ± 0.03 a
Delonix HCl – low pH	4.37	5.91 ± 0.03 cd
Eucalyptus	8.27	6.14 ± 0.03 b
Eucalyptus HCl – high pH	8.35	5.94 ± 0.03 c
Eucalyptus HCl – low pH	4.99	5.82 ± 0.03 cde
Fertilizer	-	5.69 ± 0.03 e
No fertilizer	-	5.79 ± 0.03 de
P-value	-	<0.001

Table 1.S4**.** Bean shoot biomass, root biomass, nodule biomass, number of nodules, plant nutrient content and uptake following applications of biochar prepared from seven feedstocks, at two production temperatures, with four post-pyrolysis treatments. Error is standard deviation.

Feedstock	Temperature	Treatment	Shoot biomass (g pot^{-1})	Root biomass (g pot^{-1})	Nodule biomass (g pot^{-1})	Nodules (number)	Ndfa (%)	Ndfa (mg plant^{-1})	Foliar P (mg P g plant^{-1})	Plant P uptake (mg P plant^{-1})	Foliar Ca (mg Ca g plant^{-1})	Plant Ca uptake (mg Ca plant^{-1})	Foliar Mn (mg Mn g plant^{-1})	Plant Mn uptake (mg Mn plant^{-1})
Rice	350	None	1.58±0.34	0.45±0.15	0.13±0.04	133±39	43.21±8.80	29.51±12.71	2.32±0.19	3.63±0.51	22.23±1.05	35.10±6.75	0.40±0.05	0.42±0.10
		Acetone	1.72±0.81	0.48±0.13	0.15±0.06	151±57	47.81±18.69	32.54±24.53	1.91±0.51	3.12±1.11	18.66±1.50	32.03±15.21	0.24±0.17	0.35±0.28
		HCl	2.19±0.63	0.47±0.07	0.14±0.06	128±56	39.41±18.81	27.21±19.20	1.22±0.15	2.70±0.98	23.98±1.86	52.10±12.65	0.20±0.02	0.05±0.02
		Steam	2.25±0.36	0.57±0.14	0.19±0.07	172±41	40.83±14.48	36.11±15.97	1.53±0.19	3.43±0.63	20.91±1.72	46.64±4.98	0.38±0.12	0.22±0.11
	550	None	2.18±0.76	0.48±0.17	0.17±0.05	136±41	53.19±11.33	43.16±19.43	2.24±0.23	4.80±1.45	18.07±6.79	38.89±20.56	0.40±0.21	0.31+0.13
		Acetone	2.33±0.20	0.45±0.06	0.18±0.06	171±43	57.04±6.37	55.56±11.96	1.82±0.08	4.22±0.20	17.63±2.04	40.99±5.49	0.08±0.03	0.16±0.04
		HCl	2.09±0.31	0.55±0.14	0.13±0.05	128±51	43.35±13.06	25.22±9.45	1.48±0.15	3.09±0.53	20.42±3.17	42.54±8.58	0.16±0.09	0.14±0.10
		Steam	2.21±0.47	0.55±0.25	0.17±0.03	150±27	41.84±4.13	28.04±8.35	1.71±0.12	3.76±0.50	15.02±6.18	32.42±11.74	0.08±0.03	0.11±0.05
Bagasse	350	None	2.13±0.39	0.57±0.13	0.16±0.05	257±54	44.63±17.40	27.71±14.52	3.64±0.69	7.95±2.68	26.27±2.87	55.45±9.41	0.65±0.16	0.30±0.03
		Acetone	1.92±0.57	0.49±0.15	0.16±0.04	167±51	47.86±15.08	31.20±16.32	3.96±0.64	7.04±1.84	24.07±6.76	47.53±23.37	0.46±0.11	0.24±0.05
		HCl	1.86±0.70	0.51±0.12	0.08±0.06	122±56	13.16±10.57	6.74±6.02	3.01±0.16	5.67±2.27	3.85±2.13	57.35±22.02	0.73±0.49	0.50±0.15
		Steam	1.71±0.24	0.44±0.12	0.14±0.03	122±42	37.99±2.72	18.96±2.85	2.97±0.18	5.06±0.47	30.34±2.27	51.69±5.63	0.36±0.13	0.18±0.03
	550	None	1.71±0.77	0.37±0.07	0.13±0.08	91±30	36.38±19.87	23.54±15.25	5.53±0.45	9.60±4.37	24.02±3.24	40.42±15.90	0.43±0.18	0.25±0.01
		Acetone	2.23±0.56	0.59±0.22	0.20±0.07	171±61	55.04±0.80	43.41±17.11	4.18±0.54	9.23±2.28	32.06±4.28	71.35±20.34	0.42±0.09	0.19±0.02
		HCl	1.24±0.36	0.41±0.14	0.11±0.09	105±59	32.71±11.85	13.97±9.76	3.68±0.32	4.62±1.57	30.59±1.46	38.21±12.22	0.55±0.54	0.25±0.02
		Steam	2.01±0.88	0.46±0.12	0.18±0.05	192±36	56.85±6.88	38.89±20.12	3.97±0.62	7.73±2.80	30.04±3.15	61.12±28.47	0.33±0.14	0.18±0.01
Maize stover	350	None	1.64±0.29	0.43±0.16	0.11±0.04	85±30	31.53±2.54	14.60±3.82	3.45±0.20	5.68±1.23	18.28±1.30	30.18±7.18	0.34±0.17	0.33±0.09
		Acetone	2.05±0.22	0.61±0.09	0.21±0.05	172±21	48.87±8.08	38.72±16.51	3.31±0.19	6.76±0.52	15.40±1.43	31.36±2.42	0.36±0.05	0.29±0.04
		HCl	1.67±0.27	0.35±0.08	0.02±0.02	42±20	0.00±4.72	0.00±5.95	2.96±0.28	4.96±0.96	28.70±1.73	47.88±7.51	1.09±0.20	0.58±0.24
		Steam	1.82±0.31	0.71±0.18	0.10±0.07	94±24	17.89±10.36	8.96±6.88	3.20±0.04	5.83±1.06	17.64±1.42	31.97±4.52	0.38±0.10	0.42±0.14
	550	None	1.11±0.39	0.44±0.10	0.07±0.01	82±18	26.96±1.72	7.79±3.76	3.71±0.82	4.12±1.65	16.66±1.63	18.30±5.53	0.26±0.10	0.33±0.08
		Acetone	1.88±0.96	0.50±0.12	0.16±0.07	181±72	59.31±8.72	36.62±22.96	3.33±0.51	6.39±3.28	16.55±2.66	29.29±10.59	0.37±0.16	0.57±0.33
		HCl	1.77±0.44	0.48±0.13	0.13±0.08	159±104	26.97±13.52	14.55±9.76	3.31±0.16	5.91±1.63	26.26±2.45	46.41±15.59	0.67±0.20	0.33±0.09
		Steam	1.47±0.45	0.46±0.15	0.09±0.04	107±32	34.20±14.93	17.27±10.51	4.12±0.42	6.17±2.30	17.31±2.67	25.45±8.80	0.34±0.12	0.42±0.10
Maize cobs	350	None	1.65±0.77	0.48±0.13	0.08±0.07	78±47	26.99±17.01	11.45±9.98	2.66±0.59	4.62±2.50	19.25±1.45	31.95±14.53	0.43±0.31	0.46±0.08
		Acetone	1.89±0.43	0.33±0.11	0.16±0.06	123±35	55.96±12.90	31.81±13.64	3.67±0.37	6.37±1.45	18.40±0.38	34.83±7.79	0.36±0.06	0.31±0.08
		HCl	1.79±0.23	0.54±0.07	0.08±0.04	88±15	22.07±9.95	10.05±4.13	3.01±0.11	5.38±0.57	26.06±1.50	46.72±5.90	0.59±0.11	0.26±0.03
		Steam	1.41±0.75	0.36±0.08	0.10±0.08	107±69	30.73±18.57	12.12±11.55	2.67±0.16	4.75±0.79	18.24±0.76	32.44±5.21	0.14±0.06	0.15±0.04
	550	None	1.58±0.12	0.39±0.08	0.12±0.04	90±20	38.37±12.88	16.96±10.86	2.80±1.87	4.31±2.88	13.35±8.90	20.62±13.87	0.25±0.17	0.32±0.22
		Acetone	2.31±0.24	0.38±0.08	0.19±0.03	177±37	41.74±24.53	23.19±16.47	3.75±0.30	8.62±0.52	15.91±1.24	36.73±5.18	0.40±0.10	0.31±0.12
		HCl	1.43±0.27	0.51±0.09	0.08±0.05	89±46	21.84±7.07	9.11±5.58	3.39±0.34	4.84±0.95	25.86±2.82	36.70±5.62	0.46±0.15	0.48±0.17
		Steam	1.67±0.58	0.46±0.12	0.14±0.13	81±93	39.57±10.04	21.93±2.07	3.41±0.51	5.74±2.23	18.96±2.63	30.96±8.38	0.31±0.09	0.34±0.08
Eucalyptus	350	None	2.09±0.46	0.33±0.07	0.17±0.05	175±47	34.92±5.44	22.57±9.21	2.76±0.25	5.74±1.00	18.42±0.32	38.54±8.05	0.38±0.06	0.37±0.02
		Acetone	2.19±0.52	0.31±0.12	0.15±0.02	169±20	37.97±15.00	26.05±12.60	3.00±0.36	6.46±1.00	17.82±0.60	38.69±8.69	0.31±0.09	0.31±0.11
		HCl	1.85±0.12	0.60±0.22	0.13±0.03	174±49	21.87±7.22	11.19±5.15	2.57±0.12	4.76±0.38	23.81±1.76	44.29±5.68	0.69±0.11	0.34±0.08
		Steam	1.96±0.69	0.45±0.03	0.06±0.04	71±42	17.84±17.33	11.22±13.78	2.94±0.06	5.75±1.96	18.75±0.91	36.79±13.15	0.31±0.11	0.31±0.11
	550	None	1.98±0.38	0.35±0.08	0.12±0.06	143±81	47.95±`0.23	35.16±16.38	4.37±0.49	8.60±1.33	17.94±1.33	35.24±4.27	0.32±0.07	0.52±0.27
		Acetone	1.10±0.41	0.29±0.12	0.09±0.05	183±96	58.24±6.95	21.05±9.71	2.80±0.73	3.14±1.64	13.78±4.23	15.39±8.04	0.19±0.11	0.45±0.26
		HCl	1.60±0.40	0.33±0.04	0.07±0.05	100±81	15.65±9.73	6.50±4.55	3.45±0.17	5.56±1.51	29.98±4.44	46.93±6.30	0.48±0.10	0.44±0.20
		Steam	1.08±0.57	0.36±0.08	0.05±0.06	70±59	9.11±10.95	2.07±4.10	2.99±1.33	3.74±3.34	18.88±2.84	20.40±10.65	0.17±0.08	0.40±0.10
Delonix	350	None	1.82±0.79	0.35±0.20	0.14±0.10	110±71	23.01±14.00	14.39±13.81	3.17±0.29	5.89±2.73	19.62±2.86	34.04±11.81	0.35±0.16	0.35±0.10
		Acetone	1.61±0.95	0.54±0.29	0.11±0.09	134±81	23.45±12.91	13.84±13.55	3.20±0.53	5.48±3.75	20.61±2.18	31.81±17.33	0.39±0.22	0.54±0.19
		HCl	1.74 ±0.18	0.52±0.09	0.11±0.04	120±26	16.23±8.61	7.91±4.97	3.09±0.12	5.39±0.66	25.77±2.24	44.96±6.59	0.73±0.19	0.33±0.06
		Steam	2.36±0.60	0.52±0.23	0.21±0.05	186±76	34.19±6.19	24.13±3.20	3.43±0.35	8.00±1.56	20.35±1.68	47.56±9.79	0.52±0.08	0.51±0.16
	550	None	2.20±0.20	0.37±0.08	0.20±0.03	216±70	50.30±1.70	38.78±9.33	4.04±0.32	8.87±0.41	14.76±1.64	32.36±2.52	0.43±0.04	0.39±0.15
		Acetone	2.55±0.63	0.51±0.12	0.25±0.06	251±46	52.17±2.67	39.98±10.64	3.96±0.27	10.01±2.57	15.99±0.82	40.04±8.94	0.44±0.09	0.35±0.06
		HCl	2.19±0.55	0.40±0.03	0.35±0.38	174±65	40.67±4.27	23.38±14.72	3.91±0.22	8.46±1.72	25.90±2.78	55.45±7.53	0.56±0.03	0.43±0.10
		Steam	1.53±0.78	0.53±0.12	0.15±0.02	190±63	39.35±9.00	19.96±15.38	4.15±0.26	7.55±2.11	17.06±1.02	30.88±8.01	0.47±0.07	1.07±0.76

Tea	350	None	2.36±0.78	0.55±0.15	0.17±0.06	139±60	43.90±8.08	27.92±10.44	2.97±0.04	7.02±2.28	18.11±0.20	42.67±13.81	0.47±0.19	0.39±0.05
		Acetone	2.07±0.60	0.40±0.13	0.19±0.08	176±68	52.41±11.42	35.86±17.51	3.62±0.34	7.41±1.76	17.64±1.07	36.88±11.86	0.39±0.12	0.35±0.07
		HCl	1.49±0.23	0.40±0.73	0.11±0.01	117±25	17.77±7.20	6.97±2.50	3.36±0.17	4.97±0.57	25.82±2.44	38.25±6.15	0.48±0.11	0.39±0.03
		Steam	1.67±0.76	0.59±0.10	0.26±0.05	219±34	42.42±8.90	18.80±7.58	3.16±0.09	5.33±2.49	19.82±0.78	33.37±16.00	0.31±0.14	0.38±0.08
	550	None	2.09±0.59	0.38±0.18	0.20±0.06	226±43	52.41±4.22	36.50±14.11	4.43±0.35	8.54±2.65	16.94±1.61	32.83±11.39	0.39±0.14	0.39±0.10
		Acetone	1.86±0.34	0.43±0.05	0.181±0.05	228±53	48.83±5.30	30.98±5.54	4.11±0.14	7.64±1.50	14.99±0.74	28.06±6.22	0.38±0.04	0.46±0.18
		HCl	1.80±0.12	0.42±0.14	0.27±0.28	225±115	45.75±2.76	22.16±3.01	4.57±0.28	8.23±1.08	25.40±1.96	45.79±6.36	0.52±0.11	0.76±0.60
		Steam	1.67±0.75	0.20±0.03	0.13 ±0.03	160±37	44.04±8.28	24.72±12.73	4.51±0.24	7.42±2/92	16.66±1.32	27.36±10.49	0.32±0.15	0.55±0.28
Control			0.71±0.37	0.28±0.02	0.00±0.00	22±18	3.14±2.06	1.12±1.24	1.85±0.15	1.35±0.80	24.26±6.58	15.73±4.07	0.17±0.10	0.48±0.09

Table 1.S5. Soil pH from Experiment 1. pH measured in 1:2 (w/v) H_2O. Values followed by the same letter are not significantly different; feedstock: Tukey's HSD, P<0.05, n=32 within biochar; linear contrast between all biochar and the control, P<0.05 n=3; temperature: Tukey's HSD; P<0.05; n=112; treatment: Tukey's HSD, P<0.05, n=56. Letters are not shown when differences are not significant.

Feedstock	pH (H_2O)
Rice	5.61 ± 0.02 cd
Bagasse	5.66 ± 0.02 bc
Maize Stover	5.75 ± 0.02 ab
Maize cobs	5.73 ± 0.02 ab
Eucalyptus	5.79 ± 0.02 a
Delonix	5.79 ± 0.02 a
Tea	5.81 ± 0.02 a
Control	5.40 ± 0.07 d
p-value	<0.0001
Temperature	
350˚C	5.72 ± 0.01 a
550˚C	5.75 ± 0.01 a
p-value	<0.0001
Treatment	
None	5.78 ± 0.01 a
Acetone	5.79 ± 0.01 a
HCl	5.59 ± 0.01 b
Steam	5.78 ± 0.01 a
P-value	<0.0001

Table 1.S6. Loadings for the first two principal components of Figure 1.

Variable	Component 1	Component 2
Number of nodules	0.707	0.202
Nodule biomass	0.732	0.202
Ndfa	0.646	0.105
VM	-0.250	0.123
Foliar P	0.480	0.336
Plant P uptake	0.753	0.510
Foliar Ca	-0.450	0.740
Plant Ca uptake	0.115	0.795
Foliar Mn	-0.360	0.640
Plant Mn uptake	-0.072	0.789
Biochar P	0.503	-0.173
Biochar Ca	0.629	-0.221
Biochar Mn	0.285	0.284
Soil pH	0.652	-0.304

Table 1.S7. Statistical significance of the main treatment effects.

	Number of nodules	Nodule biomass	Shoot biomass	Ndfa (mg g^{-1})	Ndfa (% total N)
	P-value				
Feedstock (F)	<0.0001	<0.0001	0.0127	<0.0001	<0.0001
Temperature (T)	0.0035	0.3156	0.8553	<0.0001	0.0009
Treatment (Tr)	<0.0001	<0.0001	0.1161	<0.0001	<0.0001
F*T	0.0605	0.2143	0.2072	0.0559	0.2934
F*Tr	0.6946	0.1316	0.3215	0.0031	0.1796
T*Tr	0.5784	0.8102	0.9080	0.4141	0.8970
F*T*Tr	0.0778	0.0356	0.1373	0.0235	0.0979

CHAPTER 2

RHIZOBIUM SURVIVAL AND INOCULATION OF BEANS IN RESPONSE TO DIFFERENT WATER AVAILABILITY WITH THE ADDITIONS OF PYROLYZED AND NON-PYROLYZED RESIDUES

Abstract

Over the past few decades elite strains of rhizobium have become commercially available for agricultural production. However, these elite rhizobium are often not as competitive as native strains under adverse edaphic conditions, primarily concerning their tolerance to soil desiccation. Biochar has been proposed as a soil amendment to reduce water stress. The effect of biochar made from sugar cane bagasse on rhizobium survival and inoculation of beans was tested in comparison to uncharred sugarcane bagasse and an unamended control in the greenhouse using a soil texture gradient under three watering regimes. When watered to field capacity immediately before planting, shoot growth did not differ between carrier materials (P>0.05). However, the number of nodules was ten- and 13-fold greater with the bagasse over the biochar or the control carriers, respectively. When pots were allowed to dry for eight weeks before planting, the bagasse carrier was the only carrier that resulted in root nodules. With intermittent drying before planting, shoot biomass with the biochar carrier was 147 and 151% greater than with the bagasse and control carriers, respectively. Nodule number using the bagasse carrier was 925% greater than the biochar carrier and no nodules were found in the control. DNA fingerprinting of the root nodules indicated that nodule occupancy was dominated by native rhizobium and not the introduced

strain. However, measured nodule occupancy (1-38%) of the introduced CIAT899 by the beans was significantly greater than expected values based on application rates (2-7%), irrespective of carrier.

Introduction

Legumes and biological nitrogen fixation (BNF) are fundamental components to both natural and agricultural ecosystems. In natural and agricultural ecosystems BNF accounts for between 50-90 Tg N yr^{-1} and around 40 Tg N yr^{-1} of N inputs, respectively (Galloway et al., 1995). In smallholder agricultural systems of developing countries BNF is often the primary source of N inputs due to limited availability of synthetic N fertilizers due to either logistical or economic constraints (Mueller et al., 2012). BNF may also reduce the dependence on external N inputs in high-input agriculture (Westhoff, 2009). In either system, efficient BNF requires intricate biological interactions between the host legume plant and the respective rhizobial symbiont. This symbiosis can be negatively affected by several edaphic conditions, principally nutrient availability, soil pH, temperature, and drought stress (Zahran, 2001). Of these, drought stress will be of increasing importance under the projected models of global climate change (Wang, 2005).

Survival of rhizobium under drought stress depends on both the adaptability of the rhizobia strain to desiccation and on the ability of the soil to buffer against changes in water status. While some free-living rhizobium have shown high survival rates under desiccation (Fuhrmann et al., 1986), many of the commercial strains have a much lower desiccation tolerance (Evans, 2005; Mnasri et al., 2007; Shoushtari and Pepper, 1985). Increasing the soil's ability to buffer against desiccation is a potent strategy as the benefits affect the rhizobial community irrespective of strain sensitivity. One proposed way to increase the resilience of the soil against desiccation is the application of biochar (Kammann et al., 2011; Karhu et al., 2011).

Biochar is derived from the thermal transformation of organic materials under reduced oxygen conditions. While the properties of different biochars can be variable depending on the initial feedstock and production conditions (Enders et al., 2012; Keiluweit et al., 2010; Kloss et al., 2012), the porosity of some biochars can be high. Due to the high porosity and surface area of some biochars, it has been hypothesized that the moisture held in these pores might protect soil microbes from desiccation during the drying of soil (Lehmann et al., 2011). Studies directly testing this hypothesis are lacking from the published literature.

The objectives of the work presented in this paper are (i) to test the ability of sugar cane bagasse biochar to protect rhizobium from desiccation following induced drought stress; and (ii) to evaluate this effect along a soil texture gradient. The hypotheses tested were: (i) biochar will promote greater survival of rhizobia and inoculation of host plants during drought events than uncharred organic matter or no additions; and (ii) use of biochar as a carrier will result in greater competitiveness of rhizobia introduced with the biochar compared to no carrier.

Methods

Soil collection

A humic Acrisol was collected from a site that had been converted to agriculture in the year 1900 (Kimetu et al., 2008; Kinyangi, 2007; Ngoze et al., 2008). The soil was air-dried, passed through a 2-mm sieve, and thoroughly homogenized.

Sand was collected from a quarry near the shores of Lake Victoria northwest of Kisumu, Kenya. The sand was predominantly alluvial and lacustrine deposits of quarts and feldspar. The sand was washed with water four times to remove all clay- and silt-sized particles then washed with a 10% HCl solution and rinsed four times with water to remove the acid. After rinsing the washed sand was air-dried and passed through a 2-mm sieve. The sand that passed through the sieve was saved for use in the experiment; the remainder was discarded.

Three separate mixtures of sand and soil were blended. These mixtures were 100:0, 75:25, 50:50, 25:75, and 0:100 % (v/v) soil and sand, respectively. The physicochemical and moisture retention characteristics of these soils are listed in Tables 2.1 and 2.2.

Biochar production

Sugarcane bagasse was collected from the Kibos Sugar factory in Kisumu, Kenya. The bagasse was air-dried and milled to pass a 200-μm sieve. Biochar was produced from a subsample of the milled bagasse in a slow-pyrolysis kiln at 550˚C. During pyrolysis a motorized paddle assembly continuously agitated the feedstock

Table 2.1. Selected soil and organic amendment physicochemical properties. The soil used for the control carriers are the same as listed below.

Soil (%)	Sand (%)	pH H_2O	CEC† (mmol$_c$ kg^{-1})	NO_3^-‡	NH_4^+‡	P#	K#	Ca# (mg kg^{-1})	Mg#	Mn#	Fe#	S#	Al#	Bulk density (g cm^{-3})	Porosity (%)
100	0	6.26	296	83.7	13.3	7	403	2017	277	509	61	33	969	0.84	0.62
75	25	5.68	134	36.1	10.4	9	274	1326	185	511	76	32	989	0.98	0.57
50	50	5.00	133	10.8	4.8	19	246	662	115	469	94	28	1409	1.13	0.53
25	75	4.48	68	3.9	3.4	31	136	434	86	457	123	33	1582	1.28	0.47
0	100	3.29	6	1.2	7.6	16	115	25	13	9	55	3	751	1.42	0.41
Biochar		9.58	4	-	-	1	6	2	1	1	12	0.3	12	-	-
Bagasse		5.25	-	-	-	-	-	-	-	-	-	-	-	-	-

†Cation exchange capacity NH_4OAc at pH7, ‡2N KCl extraction, #Mehlich-3

Table 2.2. Moisture retention characteristics for the biochar, bagasse, and sand/soil carrier materials.

Soil (%)	Sand (%)	Applied pressure (cm H_2O) 100	330	1000	3000	15000
100	0	0.42	0.40	0.30	0.26	0.23
75	25	0.28	0.28	0.18	0.17	0.14
50	50	0.16	0.15	0.11	0.10	0.08
25	75	0.09	0.07	0.05	0.05	0.04
0	100	0.02	0.01	0.01	0.01	0.00
Biochar		1.65	1.28	0.46	0.26	0.25
Bagasse		1.28	1.15	0.89	0.75	0.65

for the duration of production. The pyrolysis unit was programmed with a ramp temperature rate of 5˚Cmin^{-1} and a maximum temperature dwell time of 45 min. When the kiln had reached maximum temperature, steam was injected into the kiln and maintained until the kiln temperature had cooled to 120˚C. Once 120˚C was reached the steam was shut off.

Inoculant production

Thirty-three grams each of biochar or dried, sieved bagasse were placed separately into 45 x 90-mm high-density polyethylene (HDPE) bags and were heat-sealed shut. Soil from each of the sand/soil mixtures were also placed into HDPE bags at equivalent volumes to the biochar and bagasse treatments. The mass of these soils were 154.77 g for the pure soil, 263.72 g for the pure sand, 182.01 g, 209.24 g, and 236.48g for the 75:25, 50:50, and 25:75 treatments, respectively. After sealing, all of the HDPE bags of biochar, bagasse, and soil were autoclaved for 25 min at 120˚C. The soil moisture retention characteristics for these carrier materials are given in Table 2.

Inoculant preparation was done at the MIRCEN lab located at the University of Nairobi, Nairobi, Kenya. An initial most probable number (MPN) of native rhizobia in the soil was taken for the pure soil (Somasegaran et al., 1985). The MPN of the soil was 8.4×10^{-1} colony forming units (CFU) cm^{-3}. Initial aliquots of sterile deionized water were added to each sterilized HDPE bags of soil, biochar, and bagasse using sterilized syringes through septa stuck to the bags to bring the moisture content to 20% (w/w). The volumes of water used were 46.6 mL for the biochar and bagasse bags, 30.9 mL for the pure soil bags, 36.4 mL for the 75:25 mix bags, 41.8 mL of water for the 50:50 mix bags, 47.3 mL for the 25:75 mix bags, and 52.7 mL for the pure sand bags. The bags were massaged by hand to evenly distribute the water in the bags and then the bags were allowed to rest overnight at room temperature. A liquid culture of the *Rhizobium tropici* strain CIAT 899 was previously grown in yeast mannitol broth (YMB). A serial dilution series of the YMB culture was created and added to each bag of inoculant material (biochar, bagasse, sand/soil) to bring the total moisture content of each bag to 60% (w/w) and to ensure the concentration of rhizobium CFU in each bag was equal to the MPN of the soil. The volume of the YMB dilution added was 13.2 mL for the biochar and bagasse bags, 61.9 mL for the pure soil bags, 72.8 mL for the 75:25 bags, 83.7 mL for the 50:50 bags, 94.6 mL for the 25:75 bags, and 105.5 mL for the pure sand bags.

Greenhouse set-up and management

Air-dry soil was added to plastic pots (0.17 m diameter by 0.14 m height), filling the pot to within 10 mm of the pot rim. The mass of soil added was 1970 g for the pure soil, 2289 g for the 75:25 mixture, 2608 g for the 50:50 mixture, 2927 g for the 25:75 mixture, and 3246 g for the pure sand. Fertilizer was added to each pot at 0.09 g pot^{-1} and homogenized. The fertilizer added was comprised of 60% (w/w) of triple super phosphate, 30% (w/w) of muriate of potash, 7% (w/w) of $MgSO_4$, 1% (w/w) $Na_2B_4O_7 \cdot 10H_2O$, 1% (w/w) $MnSO_4$, and 1% ZnO. One bag of prepared inoculant was added to each soil in a full factorial design with five replicates and homogenized.

Three separate water regimes were implemented to the soils. One set of soils was watered to field capacity and allowed to dry over eight weeks (WD1). A second set of soils were watered to field capacity and allowed to dry for one week, then re-watered to field capacity (WD4). The wetting and drying of this treatment continued for eight weeks (four cycles). At the end of eight weeks both WD4 and WD1 treatments were watered to field capacity. At this time a third set of fresh inoculants was made and incorporated into an additional set of soil then watered to field capacity (WP). All treatments were planted with the Kenyan *Phaseolus vulgaris* variety KK15 from KARI (Kenyan Agriculture Research Institute, Kakamega, Kenya) on 20 May, 2013 and harvested on 25 June, 2013. Three seeds were planted per pot and thinned to one seedling one week after emergence. Once planted, the pots were maintained at field capacity for the remaining duration of the experiment by drip irrigation (The Drip Store, Vista, CA, USA). Field capacity was gravimetrically determined.

At harvest, the roots were separated from the shoots, placed into separate paper bags and dried at 60°C in a forced air oven. Prior to drying, the roots were washed and nodules were separated from the roots and placed in a plastic bag containing silica gel desiccant.

Soil analysis

Soil mineral nutrient analysis was performed on the soil prior to inoculant carrier applications. Soil pH was measured in 1:2 (w/v) deionized water. Mineral N was extracted with 2N KCl and quantified colorimetrically using a continuous flow autoanalyzer (Braun and Luebbe Autoanalyzer, SPX, Charlotte, NC, USA). Exchangeable nutrients and P were determined by Mehlich-3 extraction (Mehlich, 1984). Cation exchange capacity was determined by ammonium acetate extraction buffered at pH 7 (Sumner and Miller, 1996). All extracts were analyzed by inductively coupled plasma mass spectrometry (ICP 61E, Thermo Electron, Waltham, MA, USA).

Rhizobium culture and DNA extraction

All of the root nodules from each experimental unit were rehydrated overnight in 10 mL of sterile deionized water. The next day the water was decanted and 10 mL of a 0.8% bleach solution was added to surface sterilize the nodules. The root nodules were left in the bleach solution for four minutes then rinsed six times with sterile deionized water. Each nodule was then transferred individually to a 1.5-mL centrifuge tube (Eppendorf, Hamburg, Germany) along with 50 μL of sterile deionized water. Once the nodules were placed into the tubes, they were gently crushed with sterilized forceps to release the inner contents and briefly vortexed (VWR, Randnor, PA, USA). The nodule crushate was then streaked onto yeast mannitol auger (YMA) plates mixed with congo red. The plates were incubated at 30˚C until bacterial growth was achieved. Each successful rhizobia culture was streaked on YMA plates without congo red and incubated at 30˚C until growth was achieved. Then each individual culture of rhizobia growing on the YMA plates was then cultured in 3 mL of yeast mannitol broth (YMB) in sterilized glass test tubes and incubated at 30˚C on an orbital shaker. DNA was extracted from the YMB cultures once the media became turbid, approximately 24 hrs.

DNA was extracted using the UltraClean® microbial DNA isolation kit (MO BIO Laboratories, Carlsbad, CA, USA). The DNA samples were stored at -20˚C prior to amplification.

Polymerase chain reactions (PCR) for DNA extracted from the YMB cells were completed using a nested approach. The primers REP 1R (5'-IIIICGICGICATCIGGC - 3') and REP 2 (5' - ICGICTTATCIGGCCTAC - 3') were used to amplify the 16S portion of the DNA. All PCRs contained nuclease-free dionized water, 10X PCR buffer, 2 μmol L^{-1} $MgCl_2$, 80 μmol L^{-1} dNTP, 700 nmol L^{-1} of each primer, one unit of Sigma REDTaq Genomic Polymerase (Sigma-Aldrich, St. Louis, MO USA), and 0.5 μL of template DNA per 25 μL reaction. DNA was amplified with a PTC-200 (MJ Research, St. Bruno, Canada) thermal cycler. The PCR conditions were as follows: 1. 95˚C for 3 min, 2. 94˚C for 60 sec, 3. 55˚C for 60 sec, 4. 65˚C for 8 min, 5. repeat 1-4 34 times, 6. 65˚C for 16 min, 7. hold at 10˚C.

After PCR was completed, the PCR product was mixed with 1 μL 1:100 SYBR green and 1 μL loading dye. Five μL of this solution were added to each well in a 1.5 % TAE agarose gel. Four μL of 1Kb DNA ladder were added to the initial and final columns of each row. A positive control of DNA extracted from a pure culture of CIAT 899 was added to each gel, as well as a negative control. The gels were imaged using an EC3 Imaging System (UVP LLC, Upland, CA, USA).

Statistical analysis

All statistical analyses were performed with JMP software (SAS, Cary, NC). All procedures were performed at $P<0.05$, unless otherwise indicated. Significant treatment effects were determined using the Tukey's HSD or Students-T tests.

Results

Main treatment effects

Inoculant carrier and soil type significantly affected plant biomass, nodule biomass, and nodulation (Table 2.3). Different soil watering before planting significantly affect nodule biomass. The three-way interaction between inoculant carrier, soil watering, and soil type was also significant. However, the treatment effects differed with different soil watering regimes.

Table 2.3. Statistical significance of the main treatment effects.

Source	Shoot biomass (g pot^{-1})	Nodules (number)	Nodule biomass (mg pot^{-1})
		P-value	
Amendment (A)	0.0009	<0.0001	<0.0001
Watering (W)	0.1856	0.4146	<0.0001
Soil texture (S)	<0.0001	0.0213	<0.0001
A*W	<0.0001	0.1926	<0.0001
A*S	<0.0001	<0.0001	<0.0001
W*S	0.0007	0.0099	<0.0001
A*W*S	<0.0001	0.0134	<0.0001

Shoot biomass

Different watering prior to planting did not significantly affect shoot biomass (Table 2.3). Shoot biomass was greatest across all water treatments in the pure soil and was lowest in the pure sand. When watered to field capacity immediatly before planting (WP) in the pure sand, shoot biomass increased with the biochar carrier by 220% over the bagasse inoculant carrier and by 190% over the control carrier (Figure 2.1). When pots were allowed to completely dry out for eight weeks prior to planting (WD1) shoot biomass without organic additions was about 170% greater than with additions of either the biochar or bagasse carriers in the 50% sand-soil mixture. With periodic drying and wetting before planting (WD4) in the pure soil shoot biomass was about 250% greater with the biochar carrier relative to the bagasse and control carrier materials. With 25% sand shoot biomass was 179% greater with the biochar carrier relative to the bagasse carrier. There were no significant differences in this soil to the control carrier.

Nodulation

Varying soil water content prior to planting did not significantly affect nodulation but interactions with amendments were significant (Table 2.3). At constant field capacity (WP) the bagasse carrier significantly increased nodulation over the biochar and control carriers in all but the pure sand (Figure 2.2). In the pure soil no nodules were present with either the biochar or control carriers. With 25% sand nodulation was 1,657% greater with the bagasse carrier over the biochar carrier. No nodules were

present with the control carrier in this soil. With 50% sand nodulation was 577% greater with the bagasse carrier over the control carrier and no nodules were found with biochar. With 75% sand nodulation with the bagasse carrier was 3400% and 744% greater than the biochar and control carriers, respectively. In the pure sand nodulation with the biochar carrier was 273% and 2800% greater than the bagasse and control carriers, respectively.

No nodules were observed with any soil for the biochar or the control carriers after four weeks of continuous drying (WD1). With periodic wetting and drying (WD4), the control showed no nodules in any soil mixture, but nodulation with the bagasse carrier was 919%, 486%, 810%, and 1900% greater than the biochar carrier in the pure soil, 25% sand, 50% sand, and 75% sand, respectively. There were no nodules with biochar for the pure sand.

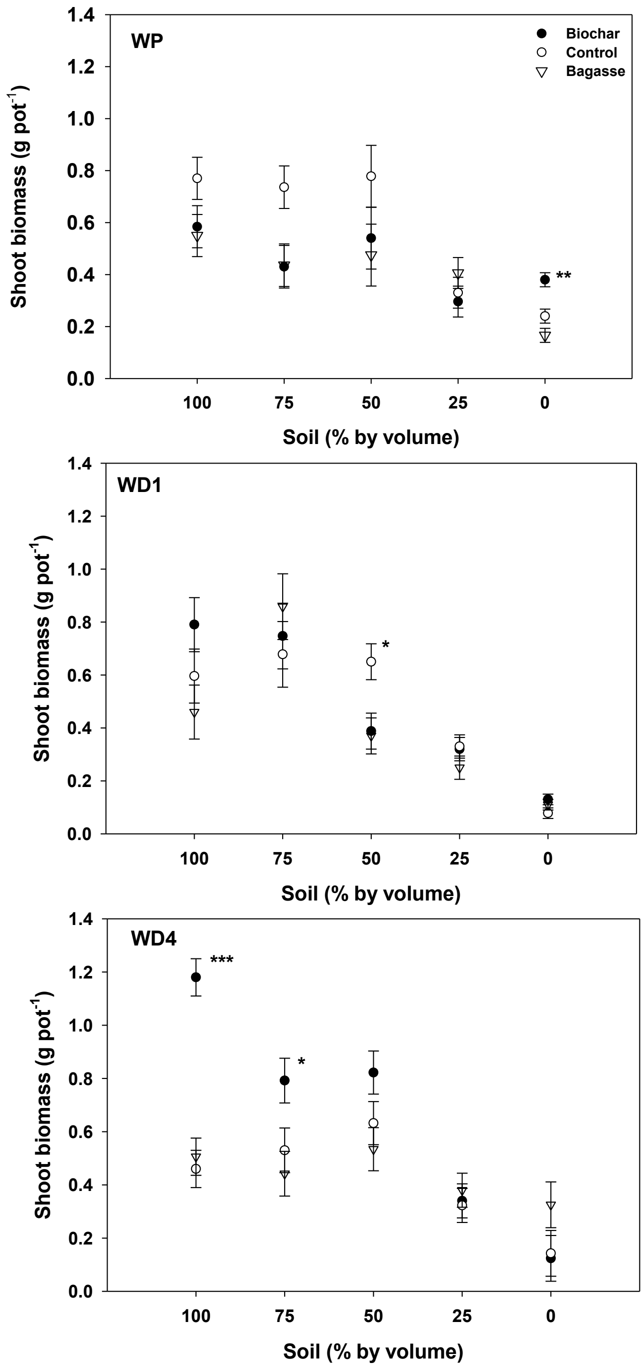

Figure 2.1. Shoot biomass in response to biochar and bagasse inoculant amendments, soil texture, and pre-planting watering (field capacity: WP; drying for 8 weeks: WD1; alternate wetting and drying: WD4). Presence of stars indicates significant differences (Tukey's HSD, *0.05>P<0.01, **0.01>P<0.0001, ***P<0.0001, $n=5$). Error bars are standard error of the mean.

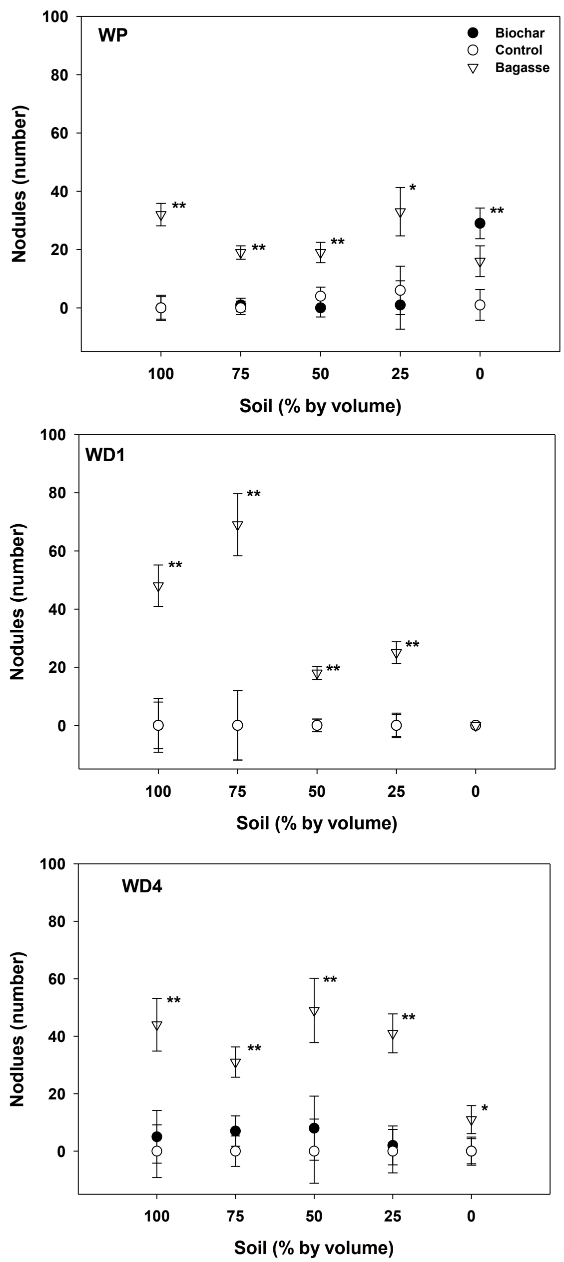

Figure 2.2. Number of root nodules in response to biochar and bagasse inoculant amendments, soil texture, and pre-planting watering (field capacity: WP; drying for 8 weeks: WD1; alternate wetting and drying: WD4). Presence of stars indicates significant differences (Tukey's HSD, *0.05>P<0.01, **0.01>P<0.0001, ***P<0.0001, n=5). Error bars are standard error of the mean.

Nodule biomass

The water treatments significantly affected the nodule biomass (Table 2.3). When watering to field capacity before planting (WP), no nodules were found in the pure soil for either the biochar or the control carriers (Figure 2.3). Nodule biomass was 12-fold greater in the 25% sand with the bagasse carrier over the biochar carrier, and control had no nodules. No significant differences in nodule biomass were observed for any carrier in the 50 and 75% sand. Nodule biomass was 4- and 3-fold greater in the pure sand with the biochar carrier over the bagasse and control carriers, respectively.

With continuous drying (WD1), no nodules were present in the pure sand for any of the carrier materials and only bagasse caused nodulation in the sand-soil mixtures or pure soil. With periodic drying-wetting (WD4) no nodules were found for the control carrier in any of the soils, and for the biochar carrier in the pure sand. Nodule biomass was 70-fold, 23-fold, 42-fold, and 174-fold greater with the bagasse carrier over the biochar carrier in the pure soil, 25% sand soil, 50% sand soil, and 75% sand soil, respectively.

Nodule occupancy

Many of the root nodules could not be cultured and a viable microbial isolates for many of the treatments could not be created (Tables 2.4 and 2.5). The nodule occupancy of the culturable nodules was not significantly correlated to culturability of the rhizobia ($r^2 = 0.009$, $P = 0.5115$). This reduces the concern for bias that certain

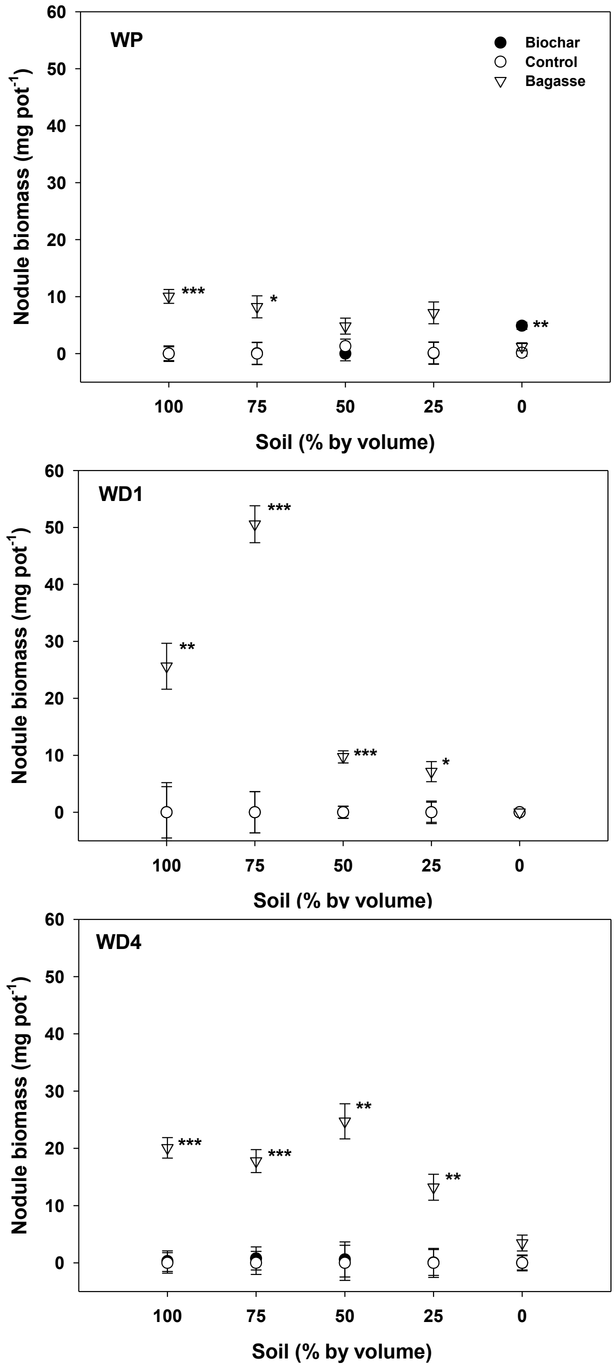

Figure 2.3. Root nodule biomass in response to biochar and bagasse inoculant amendments, soil texture, and pre-planting watering (field capacity: WP; drying for 8 weeks: WD1; alternate wetting and drying: WD4). Presence of stars indicates significant differences (Tukey's HSD, *0.05>P<0.01, **0.01>P<0.0001, ***P<0.0001, n=5). Error bars are standard error of the mean.

Table 2.4. Nodule occupancy assessed by DNA fingerprinting of culturable root nodules of *P. vulgaris* plants inoculated with the *R. tropici* strain 899 using biochar and bagasse carrier materials. Watering to field capacity before planting (WP) and alternate drying and wetting to field capacity for eight weeks before planting (WD4). Different letters indicate significant differences between amendments, no letters are shown when main effect is not significant (Students T-test, P<0.05, n=5). X^2 P-values indicate significance of difference to expected abundance of CIAT 899 of 1.7 – 6.7% based on applied amounts as a proportion of native rhizobia. NC = not culturable, NN = no nodules.

		Soil (%) 100	75	50	25	0	X^2
		Sand (%) 0	25	50	75	100	
		Wetting to field capacity (WP)					
Culturable nodules (%)	Biochar	NC	11	24	10	NC	-
	Bagasse	10	NC	10	10	NC	-
	p-value	-	-	0.2301	0.9739	-	
899 nodules (% of culturable)	Biochar	NC	0	14	18	NC	P<0.0001
	Bagasse	34	NC	23	38	NC	P<0.0001
	P-value	-	-	0.5981	0.4469	-	
		Alternate wetting and drying (WD4)					
Culturable nodules (%)	Biochar	46	8.75	7	19A	NN	
	Bagasse	66	NC	17	10B	NN	
	P-value	0.8122	-	0.4007	0.0347	-	
899 nodules (% of culturable)	Biochar	4	25	0	2	NN	P<0.0001
	Bagasse	1	NC	22	8	NN	P<0.0001
	P-value	0.1515	-	0.3439	0.2790	-	

strains of the rhizobium (either native or introduced) were more easily cultured. Nodule occupancy did not significantly differ between the biochar and bagasse carriers within any of the soils (Tables 2.4). However, nodule occupancy of the introduced CIAT899 was between 1 and 38% of all rhizobia in the nodules. This was significantly greater (x^2, P<0.0001) than the proportion introduced at 1.7 – 6.7%, when watered to field capacity before planting (WP). CIAT899 occupancy of nodules was also significantly greater (x^2, P<0.0001) than the proportion introduced to soil under periodic wetting and drying (WD4).

Discussion

Responses of introduced rhizobia

The data supported our hypotheses that the tested biochar promotes survival of introduced rhizobia and inoculation of a host plant after different drought events when rhizobia were introduced with the biochar as a carrier. The unpyrolyzed bagasse resulted in similarly increased survival as the bagasse-based biochar. To our knowledge CIAT 899 had not been introduced to these soils prior to our experiment.

With intermittent wetting and drying, the biochar carrier resulted in greater proportions of CIAT899 than expected, albeit at much lower levels of total viable rhizobial colonies than seen with the bagasse carrier. As this water treatment potentially induced the greatest water deficit, these data suggest the biochar carrier might protect the introduced rhizobium from desiccation to a greater extent than the other carrier materials.

Several studies have found that the additions of simple sugars to soil stimulated the populations of soil rhizobia (Acea et al., 1988; Pena-Cabriales and Alexander, 1983). As the bagasse is the byproduct of sugar production, it is possible that the residual sugars found in the bagasse resulted in a similar stimulation in this experiment. This could account for the greater occupancy with the introduced CIAT899 using uncharred bagasse as a carrier than without added carrier. This is further supported by greater effectiveness of press mud (another byproduct of the sugar processing industry) as an inoculant carrier over some biochars (Kibunja, 1984; Woomer, 2013). In an unpublished experiment washing press mud with acetone and 1% HCl decreased the survival of rhizobia when used as a carrier material relative to unwashed press mud (Vanek, personal communication).

Responses of native rhizobia

Between 1 - 38% of the nodules in soils amended with the bagasse carrier were identified as CIAT 899, and between 0 – 25% of the nodules with the biochar carrier were CIAT 899. This indicates that the majority of the nodules came from the native strains rather than from the strain introduced with the inoculant carriers. The only significant increase in total nodulation or nodule biomass (dominated by native rhizobia) with biochar over no additions occurred in the pure sand without reducing water availability below field capacity before planting. The biochar was incorporated into the soil, planted, and maintained immediately at field capacity for the duration of the experiment. It is unlikely that the effects seen in this treatment were due to carrier-induced reduction in desiccation. Even though the pure sand had the lowest pH and

CEC of any of the soils (Table 1), the pH did not increase after incorporation of the different carrier materials (Table 5). Whether pH effects around biochar particles could explain the differences in nodulation that are undetected by bulk soil pH measurements, was not separately assessed but may be a possibility.

When water stress was induced throughout or intermittently, the bagasse carrier resulted in greater total nodulation than either the biochar or control carriers irrespective of the soil type. After two months of continuous drying, no viable nodulation was observed with the biochar and control carriers in any of the soil types. In most of the soils the bagasse carrier, however, resulted in significant numbers of nodules on the plants, except for in the pure sand where no viable nodulation was found for any carrier. This may be partially explained by the greater water retention of the bagasse carrier at higher pressures over the biochar and control carrier materials (Table 2). However, if this was the primary cause we would expect to see this effect in the pure sand and we would also expect to see greater nodule occupancy of CIAT899 with the bagasse carrier. Neither of these was found to be true. These data suggest that the bagasse is also acting as a growth promoter by adding metabolizable sugars for the native strains of rhizobium, as discussed above, in addition to possibly providing a refuge against desiccation. In this scenario, following lower water availability, the native soil rhizobia are responding to the presence of the residual sugars in the bagasse upon rehydration and possibly to the retained soil moisture with the bagasse. This then resulted in greater nodulation with the bagasse than either the biochar or control carriers. This corroborates the observations when water was kept at field capacity.

Shoot biomass response

Differences in plant growth were most likely unrelated to biological N fixation, as rhizobial response to the biochar carrier in these soils was poor. While the pH of the biochar carrier was basic, pH changes induced with the biochar carrier would not be expected to be high as the pH of the native soil was within the optimum range for the growth of common beans. In a study that used this same soil, the authors found applications of biochar manufactured from bagasse under the same production conditions also increased bean shoot growth (Guerena et al., 2015). These changes in plant growth were correlated to greater soil P uptake and greater abundance of mycorrhizae. It is possible that these responses also occurred in our experiment. While we tried to account for nutrient deficiencies by fertilization, it is also possible that the biochar is alleviating other nutrient deficiencies not accounted for (e.g. Mo). Nutrient additions other than N with biochar manufactured from bagasse would be greater than the equivalent additions of nutrients in uncharred bagasse. When a material is pyrolyzed the proportion of the mineral components (e.g. Ca, Mg, P, etc.) increase due to the volatilization of the H, O, and C. (Enders et al., 2012). However, the effect of nutrient additions was not directly tested. While the additions of organic materials with a high C:N ratio can induce N immobilization, if this affected our experiment we would expect the bagasse carrier treatments to have a lower plant growth response than the control. The data do not support this hypothesis; there were no significant plant growth differences between the bagasse and control carriers in these soils.

Conclusion

Raw bagasse was effective at stimulating the nodulation of native rhizobium and led to a significant survival of an introduced strain. The stimulatory effect on the native strains was largely lost when the bagasse was pyrolyzed. However the pyrolyzed bagasse carrier was able to maintain viable introduced rhizobium to a greater extent than what was expected based on the amount of rhizobia introduced or total nodulation. In previous studies, both bagasse and bagasse-based biochar were effective inoculant carriers for rhizobium. This study extends these findings and shows that the investigated carriers were effective at reducing drought stress over periods of several weeks when applied separately from the seeds. It is possible that the efficacy of the raw bagasse diminishes quickly while there is evidence that the benefits from biochar-based materials can persist over time. In addition, our experiments do not inform on how seed coating with inoculants would perform. Multi-season trials, either in the greenhouse or in the field, would be needed to assess the long-term potentials for either of these materials to maintain rhizobial populations through periods of desiccation.

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APPENDIX

Table 2.S1. pH of soil amended with biochar and bagasse-based organic amendments. pH was measured in 2:1 DIW (field capacity before planting). Different letters indicate significant differences, no letters are shown when main effect is not significant (Students T-test, P<0.05, n = 4).

	Soil (%)				
	100	75	50	25	0
	Sand (%)				
	0	25	50	75	100
Biochar	5.84 B	5.88	5.62	5.70	5.13
Bagasse	5.97 A	6.02	5.87	5.74	4.85
Control	5.80 B	5.82	5.71	5.70	5.02
P-value	0.0033	0.2197	0.4416	0.9349	0.4660

Table 2.S2. Bean shoot, root, and nodule weight, and the number of root nodules in response to biochar and bagasse inoculant amendments and soil texture. Watering to field capacity before planting (WP). Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, *P*<0.05, *n=5*).

		Soil (%)				
		0	25	50	75	100
		Sand (%)				
		100	75	50	25	0
Shoot weight (g)	Biochar	0.38 A	0.30 A	0.54 A	0.43 A	0.58 A
	Bagasse	0.17 B	0.41 A	0.47 A	0.44 A	0.55 A
	Control	0.20 B	0.33 A	0.78 A	0.74 A	0.77 A
	P-value	0.003	0.4323	0.1669	0.0335	0.1441
Root weight (g)	Biochar	0.07 A	0.04 A	0.12 B	0.14 A	0.14 A
	Bagasse	0.08 A	0.06 A	0.10 B	0.14 A	0.06 A
	Control	0.04 A	0.19 A	0.34 A	0.14 A	0.13 A
	P-value	0.59	0.1996	<0.0001	0.2196	0.0452
Nodule number	Biochar	28 A	1 B	0 B	1 B	0 B
	Bagasse	10 B	48 A	24 A	23 A	42 A
	Control	1 B	6 AB	4 B	0 B	0 B
	P-value	0.0005	0.0222	0.0045	0.0007	0.0032
Nodule dry weight (mg)	Biochar	4.88 A	0.26 A	0.00 A	0.06 B	0.00 B
	Bagasse	1.20 B	7.16 A	4.82 A	8.22 A	10.04 A
	Control	0.16 B	0.13 A	1.30 A	0.00 B	0.00 B
	P-value	0.0006	0.1493	0.0697	0.0158	0.0001

Table 2.S3. Bean shoot, root, and nodule weight, and the number of root nodules in response to biochar and bagasse inoculant amendments and soil texture. Eight weeks of drying before planting (WD1). Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, P<0.05, n=5).

		Soil (%)				
		0	25	50	75	100
		Sand (%)				
		100	75	50	25	0
Shoot weight (g)	Biochar	0.13 A	0.32 A	0.38 B	0.75 A	0.79 A
	Bagasse	0.11 A	0.25 A	0.37 B	0.86 A	0.46 A
	Control	0.08 A	0.33 A	0.65 A	0.68 A	0.60 A
	P-value	0.2227	0.4117	0.0218	0.5607	0.1125
Root weight (g)	Biochar	0.02 AB	0.02 A	0.06 A	0.15 A	0.15 A
	Bagasse	0.03 A	0.05 A	0.09 A	0.11 A	0.10 A
	Control	0 B	0.04 A	0.13 A	0.09 A	0.09 A
	P-value	0.0343	0.1652	0.0622	0.2938	0.5517
Nodule number	Biochar	0	0 B	0 B	0 B	0 B
	Bagasse	0	25 A	20 A	79 A	53 A
	Control	0	0 B	0 B	0 B	0 B
	P-value	NA	0.0009	0.0002	0.0012	0.0003
Nodule weight (mg)	Biochar	0.00	0.00 B	0.00 B	0.00 B	0.00 B
	Bagasse	0.00	7.14 A	0.73 A	50.72 A	25.63 A
	Control	0.00	0.00 B	0.00 B	0.00 B	0.00 B
	P-value	NA	0.0252	<0.0001	<0.0001	0.0030

Table 2.S4. Bean shoot, root, and nodule weight, and the number of root nodules in response to biochar and bagasse inoculant amendments and soil texture. Alternate drying and wetting to field capacity for eight weeks (WD4). Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, *P*<0.05, *n=5*).

		Soil (%)				
		0	25	50	75	100
		Sand (%)				
		100	75	50	25	0
Shoot weight (g)	Biochar	0.12 A	0.34 A	0.82 A	0.79 A	1.18 A
	Bagasse	0.32 A	0.38 A	0.53 A	0.44 B	0.51 B
	Control	0.14 A	0.32 A	0.63 A	0.53 AB	0.46 B
	p-value	0.2207	0.7863	0.0748	0.0305	<0.0001
Root weight (g)	Biochar	0.03	0.05 A	0.15 AB	0.14 A	0.21 A
	Bagasse	0.05	0.07 A	0.08	0.05 B	0.08 B
	Control	0.06	0.06 A	0.16 A	0.13 A	0.10 B
	p-value	0.1836	0.6573	0.0391	0.0051	0.0014
Nodule number	Biochar	0 A	2.4 B	7 AB	7 B	6 B
	Bagasse	10 A	46 A	60 A	35 A	59 A
	Control	0 A	0 B	0 B	0 B	0 B
	p-value	0.2492	0.0046	0.0248	0.0008	0.0068
Nodule weight (mg)	Biochar	0.00 A	0.07 B	0.59 B	0.77 B	0.30 B
	Bagasse	3.47 A	13.21 A	24.73 A	17.78 A	20.09 A
	Control	0.00 A	0.00 B	0.00 B	0.00 B	0.00 B
	p-value	0.1660	0.0025	0.0001	<0.0001	<0.0001

CHAPTER 3

LANDSCAPE-SCALE MOVEMENT OF TERRESTRIAL PYROGENIC CARBON FOLLOWING LAND-USE CHANGE IN THE HEADWATERS OF THE WHITE NILE WATERSHED OF EAST AFRICA

Abstract

Pyrogenic carbon (PyC) as a residue of vegetation fires is an important and persistent part of the global biogeochemical organic C (OC) fraction. There has been recent interest in large-scale intentional applications of PyC-containing materials to landscapes to sequester C or to improve land productivity. However, understanding the biogeochemical cycling of PyC is not as robust as other forms of OC. In this paper we aim to determine the dominant translocation pathways of PyC in the context of land use change from natural vegetation to intensive agriculture. A set of experimental headwater catchments was established in the highlands of western Kenya. These catchments were located in the native forest and in recent, medium, and old agricultural conversions. Soil and water samples were taken from these catchments throughout the course of one year. Additional water samples were taken from all major tributaries of the White Nile watershed of Lake Victoria. Up to 60% losses of the initial PyC stocks occured in the first 10 years after conversion from forest from mineralization and/or erosion. However, PyC was not preferentially eroded relative to total C or non-PyC C. This was true even when scaled to the entire river watershed where PyC concentrations in the Yala river headwaters and outlet into Lake Victoria were 3.8 and 3.5% of total C, respectivley . Pyrogenic C enrichment was found with

depth in the soil profile from 5% of OC in the topsoil (0-0.15 m) to 23% of OC at 1-2 m.

Introduction

One of the forecasted consequences of climate change is increased frequency of forest fires (Flannigan et al., 2000; Scholze et al., 2006). Forest fires are known to deposit substantial quantities of pyrogenic carbon (PyC) into the terrestrial environment (Crutzen and Andreae, 1990; Lacaux et al., 1996). The global PyC generation is estimated to be between 8 - 270 Tg C yr-1, 40 % of which is generated from open biomass burning (Kuhlbusch and Crutzen, 1995; Ramanathan and Carmichael, 2008). The biogeochemical fate of these PyC deposits within soil is relatively unknown. Some have hypothesized that PyC deposits serve as a terrestrial OC sink (Goldberg, 1985) with up to 82 % of soil organic carbon (SOC) at some sites in Australia being PyC (Lehmann et al., 2008). However, PyC is disappearing from the soil, or else historic PyC production would have led to much larger soil accumulation than actually observed (Goldberg, 1985). One group of important loss pathways from soil is mineralization to CO2 by abiotic (including photo-oxidation) and biotic (microorganisms) processes and the decomposition of PyC to other organic compounds (Knicker, 2011). The rates for these processes must be slower than for uncharred OC, to explain the relative accumulation in soil despite the much lower input rates of PyC than uncharred OC to soil (Czimczik and Masiello, 2007), but depend on many factors including environmental conditions (Nguyen et al., 2010), stabilization (Cusack et al., 2012) and degree of charring (Zimmerman, 2010). Another important loss pathway has been much less investigated, and this is the physical export from the soil and its input into aquatic ecosystems (Jaffé et al., 2013; Schmidt and Noack, 2000).

The physical transport with erosion may be significant (Rumpel et al., 2006b) and more important than mineralization (Major et al., 2010) at least at initial stages of deposition (Nguyen et al., 2009). On a larger watershed scale, fluvial export has been concluded to be more important for PyC than non-PyC (Jaffé et al., 2013). However, it is not clear whether this also holds for headwaters as shown for watersheds in Siberia (Guggenberger et al., 2008) or only for observations at larger scale (Jaffé et al., 2013) which would allow conclusions about mineralization and erosion/deposition along the fluvial transport path.

In addition to erosion, eluviation of surface deposited PyC could contribute to the apparent rapid loss of surface PyC. (Major et al., 2010) found dissolved and particulate OC derived from applied char in leachate collected from an oxisol in Columbia, albeit calculated less leaching than erosion losses. Consequently, some studies showed a relative enrichment of PyC as a proportion of SOC in the subsoil for individual sites (Dai et al., 2005). Another study on former peat land soil found up to 69 % of the total PyC content was below the former plough layer depth (Leifeld et al., 2007a); this further corroborates a major pathway for PyC losses observed in surface soils over time might be due to eluviation. No studies could be found that evaluate PyC redistribution through eluviation into the subsoil or erosion to depositional areas on the scale of headwater catchments.

It is also not known whether erosion or leaching transport represents mainly losses from the landscape into stream water or rather translocations within the landscape. Within a catchment, mineral soil sediments dislodged and transported by water are often redeposited before they reach the bottom of a slope or exit the landscape (Polyakov and Lal, 2004). However, the particle density of PyC is less than the particle density of the mineral matter within soil (Brewer et al., 2009) and may be more vulnerable to erosional losses than the mineral soil. Free PyC particles not associated with the soil mineral phase could have a higher preferential erosion potential than PyC particles stabilized by adsorption to clay minerals (Rumpel et al., 2006a). On the other hand, PyC can be adsorbed to mineral surfaces which would reduce the susceptibility to erosional forces (Joseph et al., 2010) and these associations may form over time as shown by the virtual lack of net decreases in soil PyC stocks after 30 years associated with increases in metal contents on PyC particles (Nguyen et al., 2008). It is unknown whether PyC susceptibility to input into fluvial systems or redistribution within headwaters due to erosion or leaching changes over time (Hockaday et al., 2006).

The objectives of this project are (1) to quantify the magnitude and pathways of terrestrial PyC loss at a landscape scale as a function of time from initial fire event, and (2) to identify the mechanisms governing terrestrial PyC translocations within the landscape. The specific hypotheses of the project are (A) Erosion is the dominant pathways of PyC translocation and export from the landscape, and (B) PyC is preferentially eroded from the landscape relative to non PyC.

Methods

Field site

A field site was established in the highlands of western Kenya in 2006 and 2007. The study catchments form part of the headwaters of the Yala River that flows into the northeastern portion of Lake Victoria near the Kavirondo Gulf. The field site is located in the Nandi district approximately 60 km northeast of Lake Victoria at longitude 35˚0'00"E and latitude 0˚10'0"N. The mean elevation is 1800 m with a mean annual precipitation of 2000 mm and a mean annual temperature of 23˚C. Rainfall is bimodal with approximately 1200 mm of rainfall falling between April and June and approximately 800 mm of rainfall between August and October. Soils in the site are classified as humic Nitisol (Sombroek et al., 1982) weathering from granite and gneiss (Schluter and Hampton, 1997). Soils in the study area have a texture of 45-49% clay, 15-25% silt, and 26-40% sand (Kimetu et al., 2008). The original vegetation in the area is highland rainforest and the remaining forest is the easternmost extension of the Guineo-Congolian forest belt (Wass, 1995).

The Kapchorwa headwater catchments are of primary-order streams and follow a gradient of land use change. The catchments were established in duplicates (catchment set A and catchment set B) along a chronosequence of land use change from native forest and are either located within the forest (catchments FA and FB) or on lands cleared, burned, and converted to agriculture in the years 2002 (young agricultural catchments, 10A and 10B), 1996 (medium agricultural catchments, 16A and 16B), and 1950 (old agricultural catchments, 62A and 62B) (Figure 3.1). The land area of the headwater catchments ranges from a little over one to twelve hectares. All headwater catchments are located in close proximity within an area of 6 km^2. Each headwater catchment has one stream water outlet with no other hydrological input

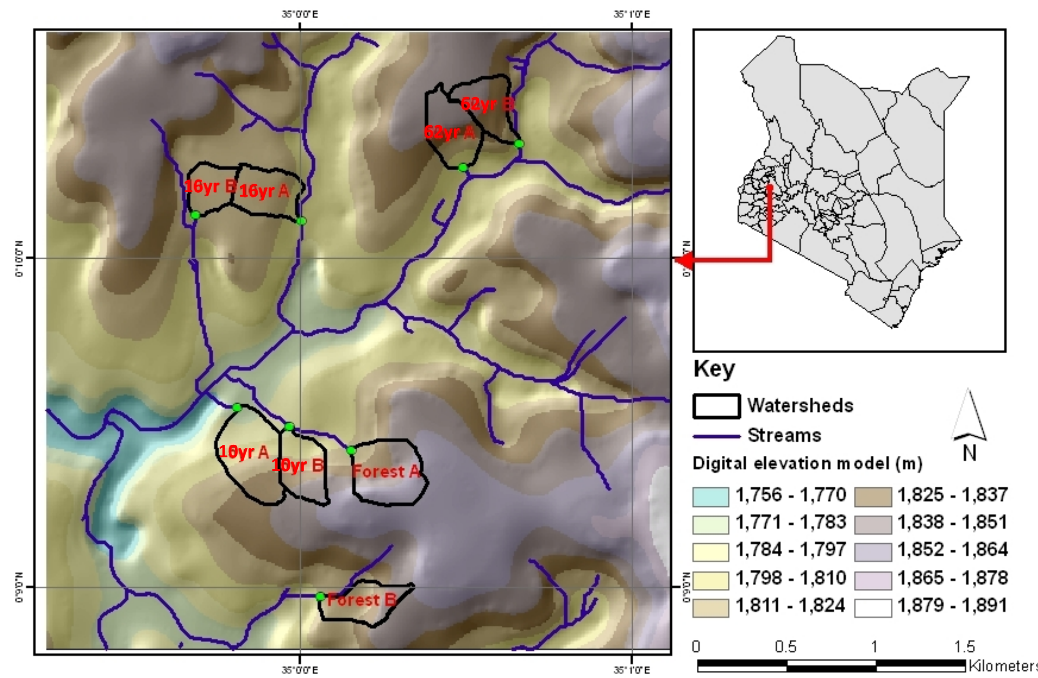

Figure 3.1. Elevation and slope maps of the study area within the Kapchorwa catchment in western Kenya and the approximate location within Kenya. Adapted from (Recha et al., 2013).

apart from rainfall. The hydrology and basic soil properties of the study are detailed in Recha et al. (2012, 2013).

The forested catchments within the study site are portions of the Kakamega-Nandi forest and are composed of mixed tropical highland species. The tree species are dominated by *Funtumia africana*, *Prunus africana, Ficus spp.*, *Croton spp.*, and *Celtis spp.* (*Glenday*, 2006). Below and above ground net primary productivity is estimated to be 15.2 Mg ha^{-1} yr^{-1} (*Hertel et al.*, 2009). The agricultural catchments

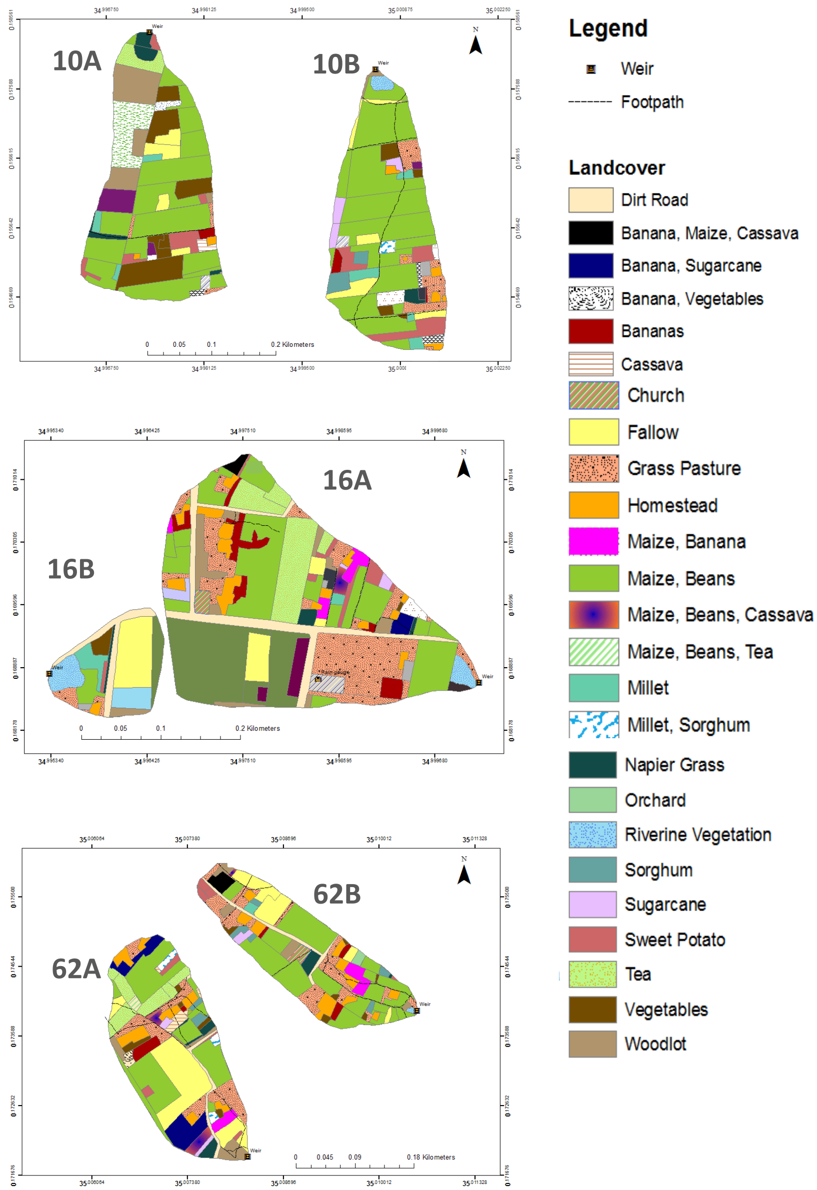

Figure 3.2. Land-use maps of the agricultural catchments within the Kapchorwa study area, Kenya. Data was taken and compiled for the long-rain season of 2013, between June and August 2013. Location of the weirs is indicated by black diamond boxes.

are complex mosaics of smallholder farming systems dominated by the annual crops of maize (*Zea mays*) and common beans (*Phaseolus vulgaris*) and the perennial crop tea (*Camillia sinensis*) (Fig. 3.2). In the spring of 2012, the local inhabitants surrounding one of the forest catchments (FA) began the process of felling trees for local charcoal production. This continued through late August of 2012. Charcoal production occurred within the catchment in scattered specific locations. Charcoal was produced using traditional earthen kilns. The large pieces of the finished charcoal were bagged and exported; the fines were left in place. There were visibly higher concentrations of charcoal left in these sites after production had finished. These sites were sampled using a protocol described in the following section and are labeled as FA-CH.

Soil sample collection

Each catchment was divided into distinct slope categories. These categories were <1 %, 1-3 %, 3-5 %, 5-10 %, 10-20 %, and > 30 %. The slope categories follow the naturally occurring contours of the land. In these landscapes the shallowest slope corresponds to the highest elevation within the landscape and the steepest slope corresponds to the lowest elevation in the landscape. Within each catchment the steepest section of the slope terminates just before the weir with little to no foot slope. In these catchments the steepest and final slope unit is an area of both soil loss and accumulation. Soil samples were taken from four random locations within each slope-category in each catchment. The randomization of the soil sampling locations was achieved using the Create Random Points function from GIS software (ArcGIS 10.1, ESRI, Redlands, CA, USA). Four samples were taken from each slope class from the 0-0.15, 0.15-0.3, 0.3-0.6, 0.6-1, and 1-2 m depths using a Dutch-style auger. Each sample was taken in triplicated within an area of 2 m^2 and homogenized in a bucket by hand. A 1-kg subsample was then taken from the bucked, air-dried, and sieved through a 2-mm sieve.

Runoff was measured using the Cornell Sprinkle Infiltrometer (Cornell University, Ithaca, NY). Low solute water was prepared at the World Agroforestry Centre Kisumu site office using a Thermo Scientific™ Barnstead™ hose nipple cartridge (Thermo Fisher Scientific). The infiltrometers were calibrated to deliver simulated rainfall at the rate of 5 mm min^{-1}. The rainfall simulation was run for one hour. All runoff, water and sediment were collected in 5-L plastic beakers. Two subsamples of the water and all of the sediment were transferred to individual 50-mL centrifuge tubes (Thermo Fisher Scientific). These samples were preserved by acidifying with 1 drop of concentrated HCl per tube and then refrigerated.

In June of 2013 small plots with intentional PyC application were established in the FB catchment. Charcoal was purchased locally within the catchment villages. This charcoal was produced from various varieties of local forest hardwoods. The charcoal was pulverized by hand to produce pieces with an average diameter of less than 10 mm. The charcoal was applied at the equivalent rate of 10 t ha^{-1} to 1 m^2 plots and lightly mixed into the top 0.1 m of the soil using hand-hoes. Four plots were randomly located within each of the slope-categories in the catchment. Soil and runoff samples were also taken from these plots.

Instrumentation, runoff, and stream water collection

Hydrological boundaries and instrumentation of the catchments was done in the year 2008; a more detailed description of the set-up is given in (Recha et al., 2012, 2013). A V-notch weir was installed in the outlet for each catchment to determine stream discharge. Stream water height was measured using capacitance probes (Odyssey Dataflow Systems Pty Ltd, New Zealand) installed near the weirs. The probes were programmed to give an average reading every two minutes. Data from these probes were downloaded biweekly. Stream hydrographs were normalized by catchment area to allow for comparisons between the various sized catchments.

Precipitation for the study period was determined by a tipping bucket rain gauge (Rain-O-Matic, Pronamic, Rinkøbing, Denmark) connected to a data logger (Hobo® Event Data Logger H07-002-04, Onset Computer Corporation, Bourne, MA, USA) installed 1 m above the ground surface. Rainfall for the study period in the catchment area was 2242 mm, with the greatest rainfall intensity of 136 mm hr^{-1}.

Stream water was sampled on a biweekly basis at the water outlet from the weir at the beginning and middle of each month. Forty mL of stream water flowing from the weirs was captured directly into 50-mL centrifuge tubes (Thermo Fisher Scientific, Waltham, MA, USA). Each water sample was preserved by adding one drop of concentrated HCl. The samples were then packed into coolers with ice packs and refrigerated.

Water samples were also collected from Lake Victoria and all of the major tributaries of this watershed. Approximate sampling locations are given in Fig. 3.3. River water was sampled during the rainy season of 2013 between the months of April and June. The rivers were sampled approximately half a kilometer from the point where the river enters the lake in order to get a representative up-stream sample. River water samples were obtained by filling two 20-L screw-cap jugs with water from the

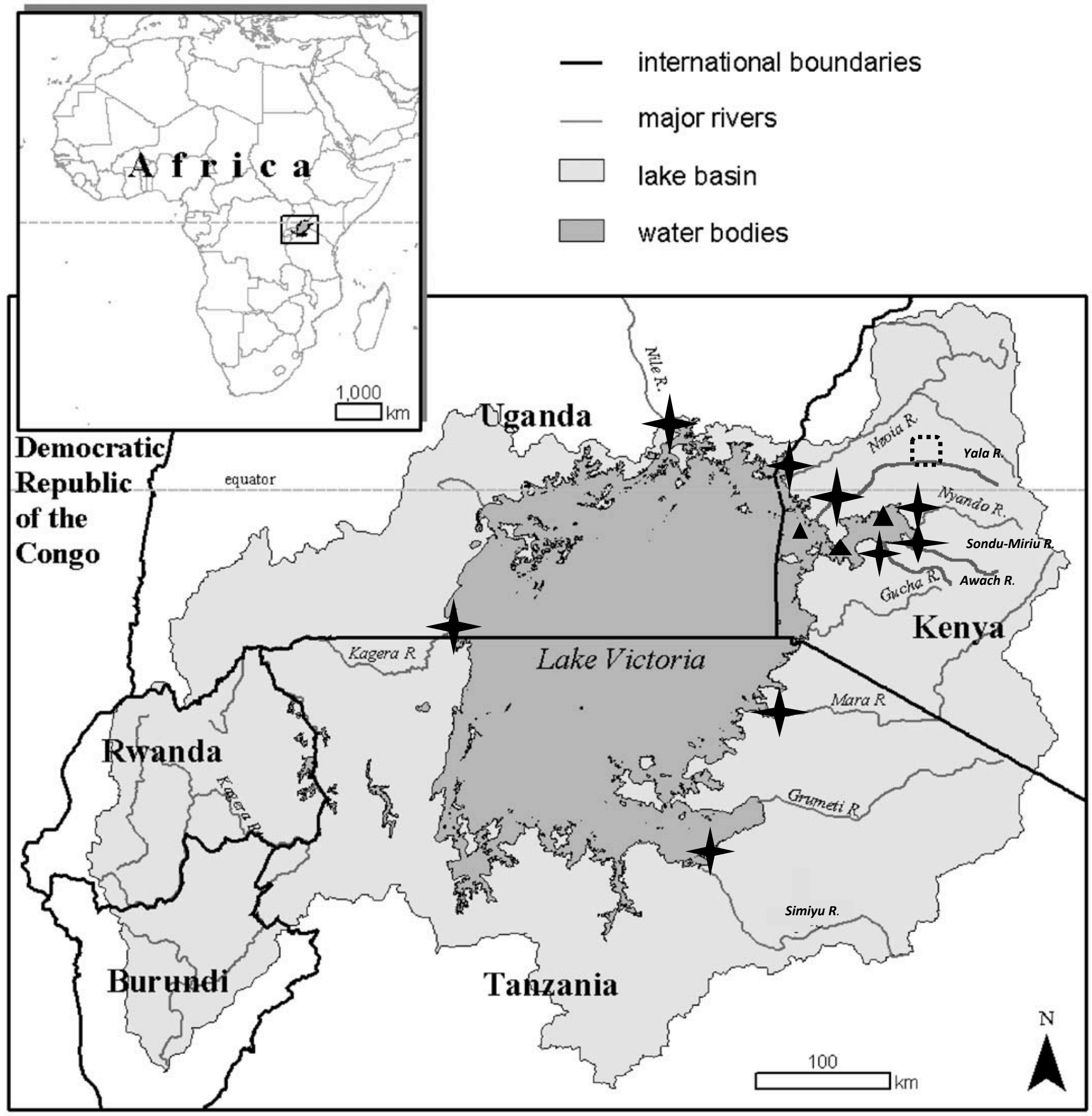

Figure 3.3. The greater Lake Victoria watershed. Location of stream-water study catchments is indicated by the hashed-box in the upper right corner of the figure. Approximate locations of river-water sampling locations are indicated by large black stars. Approximate locations of lake-lake water sampling sites are indicated by smaller black triangles.

top 2 m of the water column in the approximate middle of the river. Prior to filling, the jugs were rinsed with two washes of water from the respective river. The water from these jugs were homogenized and subsampled into a single 20-L jug which was also pre-rinsed with river water. The final jug was filled leaving less than 1 % headspace. Each sampling jug was rinsed with lake water prior to filling. The lake water samples were homogenized by pouring smaller aliquots from each sample jug into a pre-rinsed empty jug to form a representative 20-L subsample. All of the water samples were preserved by adding 10 mL of concentrated HCl to each 20-L jug. These protocols are similar to what was used in Hunt et al. (2011) and Jaffé et al. (2013).

Sample analysis

One vial of each of the Kapchorwa stream water and runoff samples was filtered through an Advantec® 0.45-μm pore-sized glass fiber filter (Toyo Roshi Kaisha, Ltd., Tokyo, Japan) and the filter as well as dissolved samples were separately processed. The river water samples were not filtered and only total contents determined. All stream water, river water, and runoff samples (whether filtered, unfiltered or sediment samples) were freeze-dried (Dura-Dry™ μP, FTS Systems Inc., Stone Ridge, NY).

Total OC and PyC was determined for all of the water, soil, and runoff samples using predictions via mid-infrared partial least square (PLS) analysis. The mid-infrared spectra for all of the stream water and runoff samples were obtained with a Bruker Tensor Series FT-IR spectrometer (Bruker Optics Inc., Billerica, MA). The instrument scanning was set to 1 scan s^{-1} for 60 scans with a ZnSe attenuated total reflectance (ATR) objective and DTGS detector. Dry, powdered samples were applied directly to the detector crystal and secured in place with a slight pressure using the ATR clamping utility tool. Spectra were acquired from the 8300-470 cm^{-1} range at 8

cm^{-1} resolution. The spectra for the soils were acquired using FTIR spectroscopy in the from 4000-602 cm^{-1} with a resolution of 4 cm^{-1} with a Bruker Optics Tensor 27 (Bruker Optics) attached to a High Throughput Screening eXTension (HTS-XT) unit with a robotic arm (Twister Microplate Handler). Soil samples were finely ground using an agate mortar and pestle and loaded into aluminum micro titer plates (A 752-96, Bruker Optics). Soil samples were then filled into four replicate wells, each well was scanned 32 times and the four spectra were averaged to account for within sample variability and differences in particle size and packing density. Reference readings were conducted with no sample loaded onto the ATR crystal.

The PLS predictions were generated from direct TOC and PyC analyses of a sub-set of the samples. Approximately ten percent (152 samples) were used for the PLS calibration. The samples used for calibration were chosen to represent a broad spectrum of PyC contents to give the PLS model maximum predictive power. The PLS model for PyC and TOC prediction had a r^2 equal to 0.92 and 0.84, respectively, and root mean squared error of 0.48 and 0.57, respectively. Of these sub-samples, one sample subset was used to determine TOC by Dumas combustion on a Costech ECS 4010 (Costech Analytical Technologies Inc., Valencia, CA); since soils are acid and the parent material is granite and gneiss, total C is equivalent to total organic C (TOC). PyC was determined by TOC quantification using Dumas combustion after hydrogen pyrolysis (hypy) (Costech Analytical Technologies Inc., Valencia, CA). The hypy process to determine PyC is described in detail in Love et al. (1995). Sub-samples of the soils and the freeze-dried water samples were loaded with a Mo catalyst at 5% by weight using an aqueous/methanol 0.2 M solution of ammonium dioxydithiomolybdate [$(NH_4)_2MoO_2S_2$], and then pyrolyzed from 50˚C to 250˚C at 300˚C min^{-1}, and then from 250˚C to 600˚C at 8˚C min^{-1} under hydrogen pressure of 15 MPa. Hydrogen sweep gas flow of 5 L min^{-1} was used to remove gaseous products from the reactor vessel. Non-PyC was determined by subtraction.

Calculations of PyC and TOC loads

In the Kapchorwa catchments the daily discharge rates were summed across a two-week period corresponding to the bi-monthly date of sampling for PyC and TOC until the day before the next sampling date. The corresponding PyC and TOC concentrations were multiplied by the sum of total discharge for this time period to give load yields. These loads were then used to calculate average annual PyC and TOC for the study period. These values provide estimates for annual base flow not including storm flow or overland flow. In these catchments, base flow was measured to be between 70 and 80% of total discharge (Recha et al., 2012).

Estimated average annual water discharge values for the greater Lake Victoria watershed rivers were taken from literature. Estimated annual exports of TOC and PyC by base flow were calculated by multiplying the concentrations from the sampled water by these published annual discharge values, assuming a certain degree of similarity between the temporal dynamics in the river systems around Lake Victoria and our detailed assessments of the headwaters and Yala River system. These export values have to be taken with caution and provide a starting point for further inquiry.

Statistical analysis

All statistical analyses were performed with JMP software (SAS, Cary, NC). All procedures were performed at $P<0.05$, unless otherwise indicated. Significant treatment effects were determined using the Tukey's HSD test.

Results

Soil – catena

Within the forest catchment FA no significant differences were observed in the investigated topsoil OC fractions between any of the slope categories (Table 3.1; for maps see Supplementary Figures 3.S1 and 3.S2). Despite intentional additions of PyC, total PyC across the catchment did not change with slope in the plots with experimentally applied charcoal (catchment FB). Within 10 years after forest conversion, significant differences of all of the soil OC fractions between positions higher and lower in the landscape were found. After 10 years of continuous cultivation

Table 3.1. Soil total C and PyC contents and stocks of natural and agricultural catchments in the headwaters of the Yala River, Kenya. Soil was taken from the top 0-0.15 m. Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, $P<0.05$, $n=4$). CH represents the charcoal production sites. PyC represents the research-applied charcoal plots.

Slope unit (% slope)	TOC (mg g^{-1})	TOC (Mg ha^{-1})	Non-PyC (mg g^{-1})	Non-PyC (Mg ha^{-1})	PyC (mg g^{-1})	PyC (Mg ha^{-1})	PyC (% of TOC)
Catchment FA							
CH	75.0	90.0	61.5	73.8	13.5 A	16.2 A	17.58 A
<1	69.8	83.8	66.4	79.7	3.4 B	4.1 B	4.98 B
1-3	91.2	109.5	86.1	103.4	5.1 AB	6.1 AB	5.52 B
3-5	72.8	87.4	67.7	81.2	5.1 AB	6.1 AB	7.01 B
5-10	63.5	76.3	56.8	68.1	6.7 AB	9.1 AB	11.67 AB

10 – 20	72.2	86.6	68.2	81.9	3.9 B	4.7 B	5.63 B
P-value	0.4505	0.4505	0.1784	0.1784	0.0016	0.0016	<0.0001
Average	73.8a	88.57a	65.8a	78.94a	8.02a	9.63a	10.95a
Catchment FB							
<1	73.6 A	88.3 A	71.1 A	85.3 A	2.5 AB	3.00 AB	3.46 B
1 PyC	56.2 AB	67.4 AB	53.6 ABC	64.4 ABC	2.5 AB	3.1 AB	4.61 AB
1-3	71.6 A	85.9 A	68.0 AB	81.6 AB	3.6 AB	4.3 AB	5.41 AB
1-3 PyC	64.8 AB	77.7 AB	60.7 ABC	72.9 ABC	4.1 A	4.9 A	6.43 AB
3-5	78.3 A	94.0 A	75.2 A	90.2 A	3.1 AB	3.7 AB	4.10 B
3-5 PyC	39.1 B	47.0 B	35.5 C	42.6 C	3.6 AB	4.4 AB	9.48 A
5-10	55.4 AB	66.5 AB	52.9 ABC	63.5 ABC	2.5 AB	3.0 AB	4.51 AB
5-10 PyC	45.7 B	54.8 B	44.2 BC	53.1 BC	1.5 B	1.7 B	3.19 B
P-value	0.0003	0.0003	0.0004	0.0004	0.0425	0.0425	0.0115
Average	60.7b	72.90ab	57.9ab	69.50ab	2.84b	3.42b	4.99b
Catchment 10A							
<1	46.2 AB	63.0 AB	43.0 AB	58.7 AB	3.1 AB	4.3 AB	6.96
1-3	39.8 B	54.3 B	37.7 B	51.5 B	2.1 B	2.8 B	5.44
3-5	59.5 A	81.2 A	55.9 A	76.3 A	3.6 AB	4.9 AB	6.14
5-10	61.3 A	83.6 A	56.5 A	77.1 A	4.8 A	6.6 A	7.87
P-value	0.0073	0.0073	0.0127	0.0127	0.0052	0.0052	0.2981
Average	61.7bc	70.54ab	48.3bc	65.87ab	3.42b	4.43b	6.60b
Catchment 10B							
1	18.2 B	24.8 B	16.9 B	23.0 B	1.3 C	1.8 C	7.31 AB
1-3	29.2 B	39.8 B	26.9 B	36.8 B	2.2 BC	3.0 BC	7.80 A
3-5	65.4 A	89.3 A	61.6 A	84.0 A	3.8 AB	5.2 AB	5.82 AB
5-10	67.0 A	91.5 A	61.9 A	84.5 A	5.1 A	7.0 A	7.53 AB
10-20	59.4 A	81.0 A	55.7 A	76.1 A	3.6 AB	4.9 AB	6.11 AB
20-30	66.7 A	91.0 A	63.3 A	86.4 A	3.4 ABC	4.6 ABC	5.06 B
P-value	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	0.0004	0.0207
Average	51.0bc	69.57ab	47.7bc	65.14ab	3.25b	4.67b	6.60b
Catchment 16A							
<1	56.1	86.8	53.5	82.6	2.7	4.2	4.72
1-3	51.1	79.0	48.3	74.6	2.9	4.5	5.83
3-5	39.2	60.5	36.9	57.1	2.3	3.5	7.11
5-10	40.6	62.7	38.2	59.0	2.4	3.6	5.85
10-20	57.2	88.9	55.3	85.5	2.2	3.4	3.95
P-value	0.3712	0.3712	0.3465	0.3465	0.6477	0.6477	0.1991
Average	49.6bc	75.57ab	47.1bc	71.75ab	2.51b	3.82b	5.51b
Catchment 16B							
<1	57.9	89.5	56.1	86.6	1.8	2.83	3.71
1-3	74.8	115.6	72.7	112.3	2.1	3.26	2.93
3-5	38.4	59.3	36.2	56.0	2.2	3.36	6.36
5-10	37.0	57.2	34.9	54.0	2.1	3.22	6.08
P-value	0.1314	0.1314	0.1246	0.1246	0.6948	0.6948	0.0548
Average	45.9bcd	74.06ab	43.9bcd	70.98ab	2.02	3.08b	5.11b
Catchment 62A							

<1	29.5	51.7	27.2	47.8	2.3	4.0	8.01 AB
1-3	43.1	75.7	40.3	70.7	2.8	5.0	6.98 AB
3-5	36.2	63.4	32.9	57.8	3.2	5.6	8.90 A
5-10	27.7	48.6	25.5	44.8	2.2	3.8	8.11 AB
10-20	31.1	54.6	29.0	50.9	2.1	3.6	6.94 AB
20-30	24.5	41.9	22.9	40.1	1.6	2.9	7.50 AB
>30	33.5	58.8	31.9	55.9	1.6	2.9	4.92 B
P-value	0.3987	0.3987	0.4153	0.4153	0.0996	0.0996	0.0683
Average	36.1cd	56.54b	29.9d	52.57b	2.26b	3.97b	7.34b
Catchment 62B							
<1	31.7	55.6	30.0	52.7	1.7	2.9	5.27 B
1-3	25.5	44.8	23.6	41.5	1.9	3.3	7.71 A
3-5	41.2	72.4	38.9	68.2	2.4	4.1	5.75 AB
5-10	41.0	72.0	39.0	68.6	2.0	3.4	4.81 B
10-20	44.2	77.6	42.5	74.6	1.7	3.0	4.06 B
20-30	37.7	66.2	36.2	63.5	1.5	2.7	4.76 B
P-value	0.4123	0.4123	0.3958	0.3958	0.0919	0.0919	0.0010
Average	32.2d	63.39b	34.3cd	60.20ab	1.81b	3.19b	5.41b
P-value total	<0.0001	0.0002	<0.0001	0.0024	<0.0001	<0.0001	<0.0001

stocks of TOC, non-PyC, and PyC were 30, 32, and 50% greater in lower (with greater slope) than higher (with less slope) landscape positions in catchment 10A; and 264, 274, and 280% in catchment 10B, respectively (Table 1). Over time, the landscape distribution of PyC reversed and the PyC stocks were slightly greater at higher landscape positions ($P<0.1$; Table 3.1). The proportion of PyC in TOC was 80-90% greater in higher landscape positions relative to the lower positions 62 years after burning, and average PyC proportions were 7.7% of TOC (ranging from 3% to 11% weighted average for each watershed).

Soil – depth profiles

Within the top 0.15 m, TOC concentrations decreased from 75 mg g^{-1} in the forested catchment to 30 mg g^{-1} in the oldest agricultural catchments (Figure 3.4). In all of the catchments, TOC concentration decreased to 10 mg g^{-1} with depth to 2 m.

Surface PyC concentrations were greatest, 1.5% w/w, in the charcoal production sites within the FA catchment compared to 0.4% in the non-charcoal production sites. Pyrogenic C concentrations in the surface soil decreased to between 0.3 – 0.2% in the agricultural catchments for one set of catchments, while no difference between forest and agriculture was seen in the other. In the subsoil, there were no significant differences in PyC concentrations between the charcoal productions sites and the non-charcoal production sites at about 0.4% w/w. Soil PyC concentrations at 2 m in the agricultural catchments decreased by more than 50% relative to the forest catchment to between 0.2 - 0.1%.

Soil PyC as a proportion of TOC increased with depth from 7% in the surface of the forest catchments to 10 – 24% at 2 m and between 5 – 7% in the surface of the agricultural catchments to 7 – 13% at 2 m (Figure 3.4). In the top 0.15 m of the soil this proportion was significantly greater (17% of TOC) in the charcoal production sites within the forested watershed relative to the non-charcoal production sites (7%) or the agricultural catchments (5-7%). Topsoil PyC and non-PyC were weakly but significantly correlated (r^2=0.37; Figure 3.5a).

Dissolved and sediment runoff from rainfall experiments

Soil OC fractions in runoff dissolved organic matter or sediments induced by experimental rainfall were not significantly different between any of the catchments (Table 3.2). No correlation was found between PyC in the soil and the sediment captured in the induced erosion (r^2=0.04; P=0.14; Figure 3.7a); neither with total (r^2=0.28) or dissolved (r^2=0.17) PyC, data not shown) and the PyC values in runoff sediments (Table 3.2) were two orders of magnitude lower than those found in the soils (Table 3.1).

Discharge and base flow C and PyC concentrations

Total OC concentrations in the stream water base flow were greater in the medium and old agricultural catchments then in the forest or young agricultural catchments (Figure 3.6). There were no obvious trends in base flow PyC concentrations between any of the catchments. PyC and non-PyC were highly

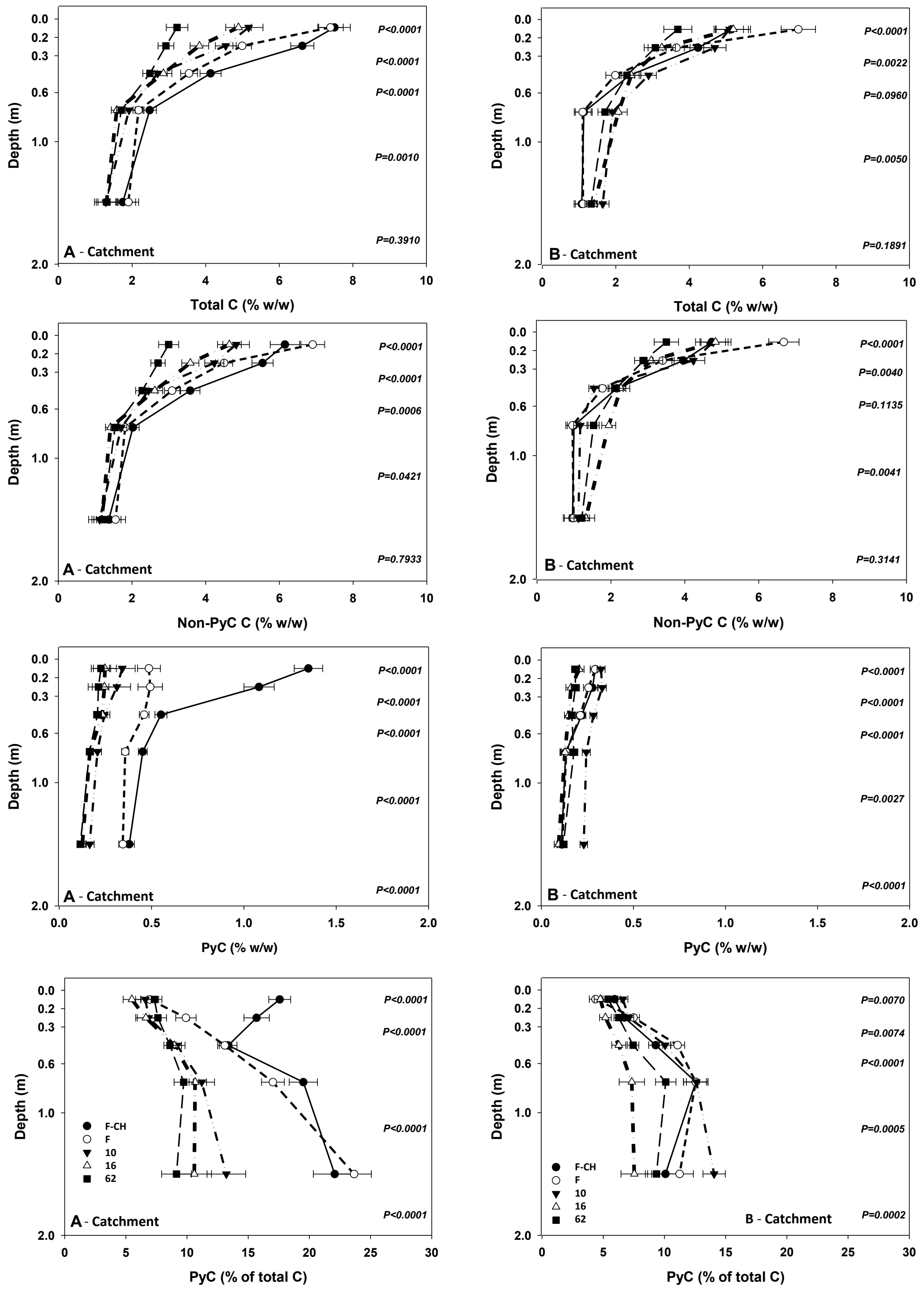

Figure 3.4. Soil profile total C and PyC in natural and agricultural catchments in the headwaters of the Yala River, Kenya. Statistical significance from each depth is

indicated by the corresponding *P*-value (Tukey's HSD, $P<0.05$, FA $n=36$. FB $n=48$, 10A $n=25$, 10B $n=36$, 16A $n=30$, 16B $n=24$, 62A $n=42$, 62B $n=36$ for averages of all slope positions). F-CH is the charcoal production site data from catchment FA (left side are catchments A, right catchments B).

correlated for dissolved species (Figure 3.5c), whereas this was not the case for sediments (Figure 3.5b). Baseflow streamwater PyC concentrations as a fraction of OC were not related to the PyC concentrations in the top soil (0-0.15 m) (Figure 3.7b). However, baseflow streamwater PyC concentrations were at least weakly correlated to soil PyC concentrations in the 1-2 m portion of the soil column (Figure 3.7c).

Annual TOC and PyC exports

Annual TOC and PyC exports from the catchments increased with conversion age from the forest to the medium agricultural conversion catchments then decreased in the oldest agricultural catchments (Table 3.3). On average, annual PyC exports were two orders of magnitude smaller than TOC exports. However, the proportion of PyC to TOC in the annual export was greater in the forested catchments than in the agricultural catchments. The average proportion of PyC to TOC in exports from the agricultural catchments was 73% of the initial value exported from the forested catchments 10 years after conversion from forest. This value fell by an additional 24% to 49% of the initial value 16 years after conversion from forest. Sixty-two years after conversion the average proportion of PyC of TOC in the agricultural catchments was 36% of the initial value exported from the forest catchments.

Estimated base flow exports of TOC and total PyC (including both dissolved and sediment) from the major rivers flowing into and out of Lake Victoria, when normalized by catchment area, were approximately two orders of magnitude greater than the exports from the Kapchorwa catchments (Table 3.4). Estimated PyC exports ranged from 0.03 kg ha^{-1} yr^{-1} leaving Lake Victoria through the River Nile (the White Nile) at Jinja, Uganda to 0.6 kg ha^{-1} yr^{-1} leaving the Gucha River in Kenya, albeit with very limited sampling intensity. However, the proportion of PyC to TOC from these rivers still covers, with 1-10% (flow-weighted average of 3.8%), a similar range to what was measured in the Kapchorwa catchments, and was only slightly smaller in the outlet of Lake Victoria into the White Nile (1.1%).

Discussion

Redistribution of PyC within the catchments

Charcoal production and PyC deposition was observed to occur in concentrated locations throughout the forested catchment (FA), rather than as a more uniform deposition. This pattern is supported by other observations in similar forest systems in Africa (Bleher et al., 2006; Geist and Lambin, 2002; Müller and Mburu, 2009). On average, PyC stocks resulting from charcoal production in these sites were equal to 10 Mg PyC ha^{-1}, with an average native (prior to this charring event) PyC content of 6 Mg ha^{-1}, calculating to an addition of 4 Mg ha^{-1} in the study sites. In comparison, Nguyen et al. (2008) estimated a PyC deposition by forest clearing of about 3.5 Mg PyC ha^{-1} through extrapolation of soil PyC stocks in the same region, matching our estimates. These values calculate to appr. 1% of aboveground C of

Table 3.2. Total organic C and PyC contents captured in water and sediment runoff from infiltrometer plots of natural and agricultural catchments within the Kapchorwa catchment of western Kenya. No runoff (NR) was captured in the catchment 10A. Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, $P<0.05$, FA $n=36$, FB $n=48$, 10A $n=25$, 10B $n=36$, 16A $n=30$, 16B $n=24$, 62A $n=42$, 62B $n=36$). FB-PyC represents the researcher applied charcoal plots.

Site	TOC[a] (mg L^{-1})	PyC[a] (mg L^{-1})	PyC (% of TOC)	DOCtot (mg L^{-1})	DPyC (mg L^{-1})	DPyC (% DOCtot)	TOC (g ha^{-1})	PyC (g ha^{-1})	DOCtot (g ha^{-1})	DPyC (g ha^{-1})	Sediment TOC (mg g^{-1})	Sediment PyC (mg g^{-1})	Sediment PyC (% TOC)
FA	0.152	0.003	1.3	0.148	0.003	1.8	580	7.63	535	9.60	0.063	0.001	1.3
FB	0.125	0.003	2.4	0.104	0.002	1.7	318	7.06	274	4.85	0.004	0.000	2.4
FB-PyC	0.179	0.003	2.0	0.204	0.003	1.7	422	8.54	542	7.06	0.077	0.002	2.0
10A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
10B	0.168	0.002	1.6	0.139	0.003	2.2	412	6.22	325	7.03	0.175	0.003	1.6
16A	0.166	0.003	1.8	0.182	0.004	1.9	390	6.86	446	8.45	0.668	0.016	1.8
16B	0.163	0.003	1.8	0.157	0.003	1.9	457	8.02	437	8.42	0.063	0.002	1.8
62A	0.167	0.003	1.8	0.154	0.003	2.1	361	6.43	332	6.64	0.577	0.010	1.8
62B	0.130	0.003	1.8	0.138	0.003	1.7	270	4.70	308	5.27	0.063	0.001	1.8
P-value	0.4331	0.3411	0.5493	0.2926	0.3652	0.8160	0.3137	0.2902	0.4223	0.5397	0.9086	0.8254	0.5493

[a]Flow-weighted averages

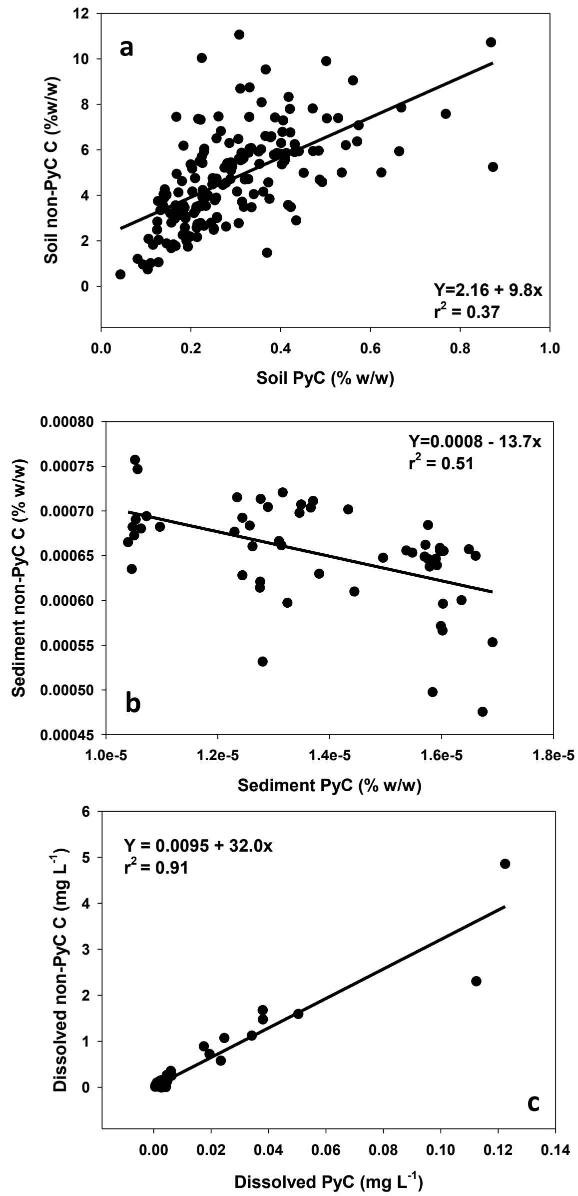

Figure 3.5. Linear correlations of the concentrations of PyC and non-PyC in soil (0-0.15 m), sediment captured from induced runoff (a), and stream (b) and river water (c). *P*-value for all correlations is <0.0001.

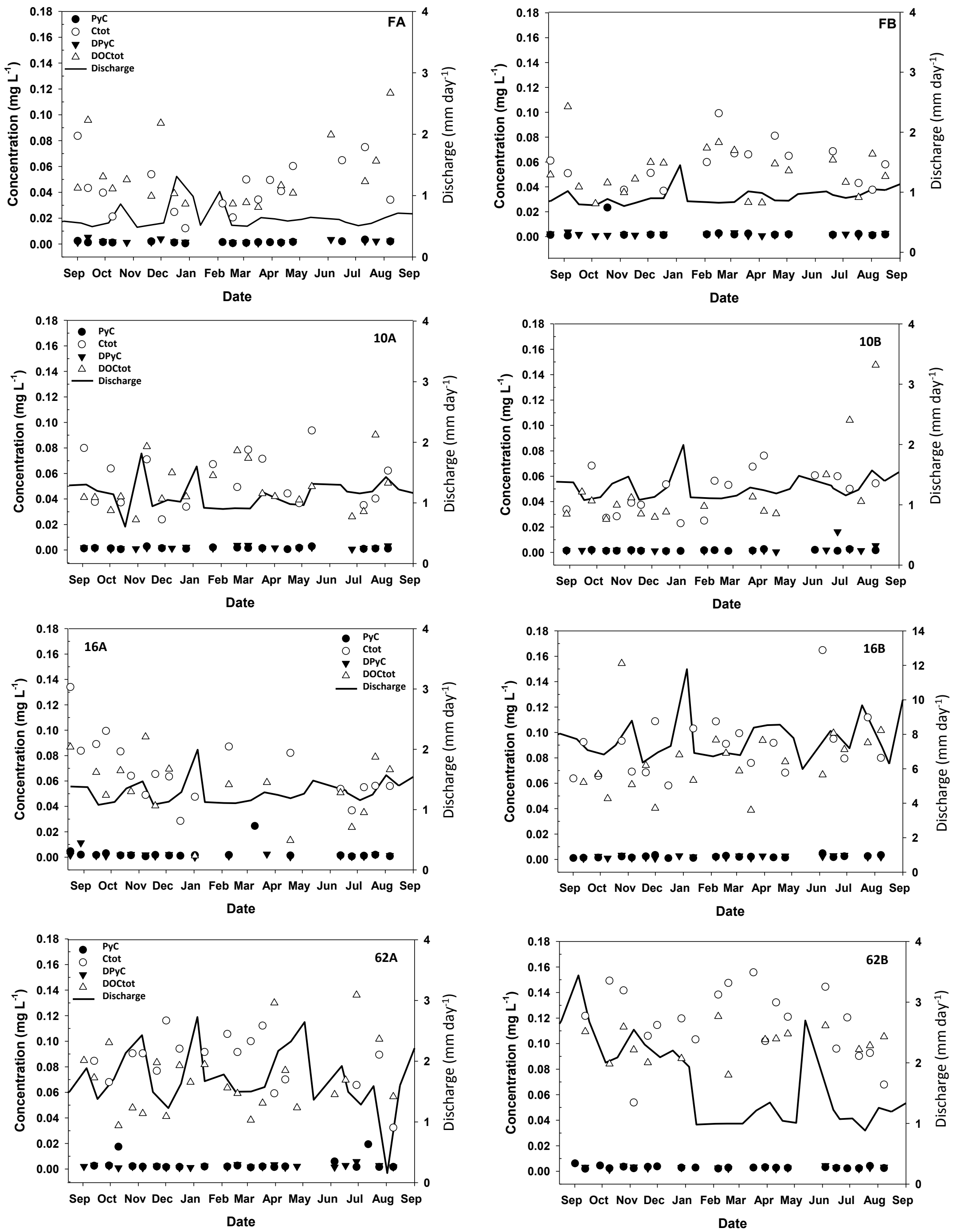

Figure 3.6. Bi-weekly discharge and stream water concentrations of TOC and PyC in natural and agricultural headwater catchments of the Yala River, Kenya. Note scale change in the hydrograph for catchment 16B.

Table 3.3. Annual amounts of total C and PyC (sediment and dissolved species) as well as dissolved species leaving natural and agricultural catchments in the Kapchorwa catchment, Kenya.

Site	Total C (kg ha^{-1} yr^{-1})	PyC (kg ha^{-1} yr^{-1})	PyC (% TOC)	DOCtot (kg ha^{-1} yr^{-1})	DPyC (kg ha^{-1} yr^{-1})	DPyC (% DOCtot)
FA	0.06	0.002	3.2	0.067	0.002	3.0
FB	0.19	0.006	9.5	0.121	0.004	3.3
10A	1.08	0.014	1.3	0.152	0.005	3.3
10B	1.36	0.046	3.4	0.269	0.010	3.7
16A	2.84	0.055	1.9	1.762	0.041	2.3
16B	2.19	0.052	2.4	1.895	0.051	2.7
62A	0.67	0.014	2.1	0.441	0.013	2.9
62B	1.08	0.026	2.5	0.540	0.047	8.7
Average	1.18	0.027	3.3	0.656	0.022	3.7

330 Mg ha^{-1} converted to PyC, which is in the range, 0.7-2.9%, reported for burning of tropical forests (Forbes et al., 2006).

Within the forested catchments, apart from these charcoal production sites, the soil PyC was evenly distributed across the landscape. Ten years after forest clearing, however, there were clear indications of PyC redistribution across the landscape, between 1.04 and 1.6 Mg ha^{-1} or 66 and 74% of the PyC was lost from sites upslope and there was a corresponding accumulation of 1.9 and 2.9 Mg ha^{-1} in regions downslope near the areas where the springs are located. Physical movement likely accounts for these differences in PyC, as differential mineralization or deposition by fire in situ may not result in such clear changes across the landscape over time. These differences in PyC stocks and concentrations within the landscape disappeared 16 years after forest conversion to agriculture. Sixty two years after initial forest clearing between 41 – 80% of the initial stocks of PyC remained. The data indicate that soil PyC within the landscape is vulnerable to physical movement in approximately the first decade after forest clearing and deposition, after which the PyC stocks are stabilized. This mirrors conclusions by Nguyen et al. [2008] from plot-scale studies in the same region.

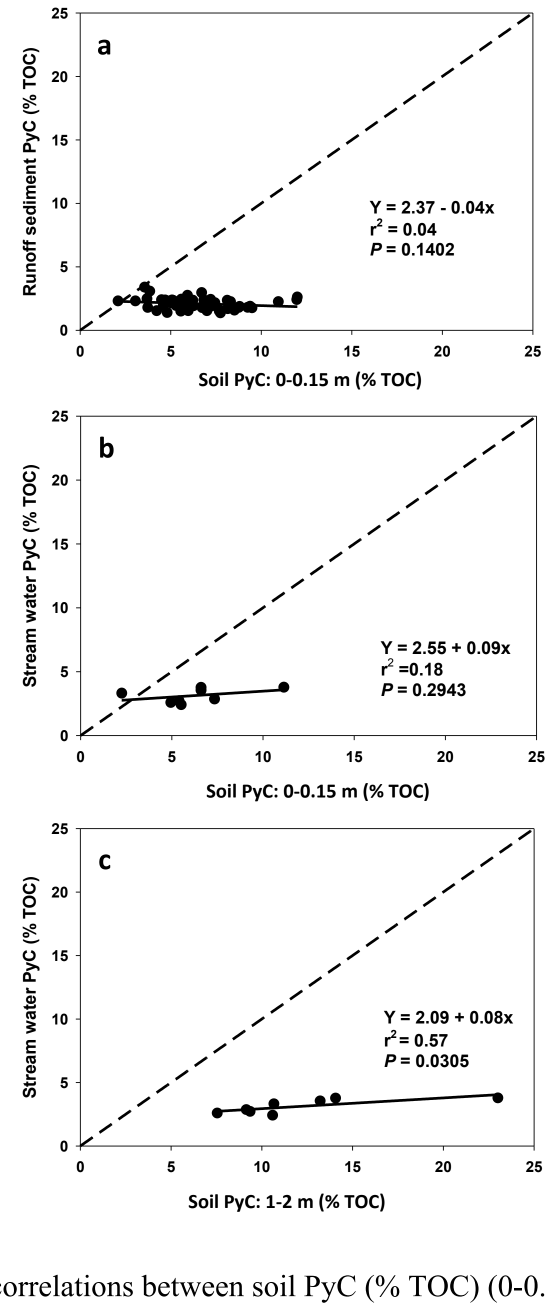

Figure 3.7. Linear correlations between soil PyC (% TOC) (0-0.15 m) and runoff sediment PyC (% TOC) (a), soil PyC (% TOC) (0-0.15 m) and stream water PyC (% TOC) (b), and soil PyC (% TOC) (1-2 m) and stream water PyC (% TOC) (c). Hashed line represents a 1:1 relationship. Solid line is the regression line of the data points that corresponds to the accompanying equation, Pearson correlation coefficient, and *P*-value.

Table 3.4. Total C and PyC concentrations, stocks, and annual exports in the greater Lake Victoria watershed, the headwaters of the White Nile.

Site	Native ecological zone	Catchment area (km^2)	Average annual discharge ($m^3 s^{-1}$)	TOC ($mg L^{-1}$)	PyC ($mg L^{-1}$)	PyC (% total C)	TOC ($kg^{-1} ha^{-1} yr^{-1}$)	PyC ($kg ha^{-1} yr^{-1}$)	TOC ($Gg yr^{-1}$)	PyC ($Gg yr^{-1}$)
R. Yala	Highland forest	3,240	27[1]	13.5	0.5	3.5	33	0.14	10.8	0.4
R. Nzoia	Highland forest	12,900	118[1]	14.0	0.6	4.6	372	0.19	479.3	22.3
R. Nyando	Savannah	3,500	13[3]	20.3	1.6	7.7	22	0.46	7.7	0.6
R. Awach	Savannah	1,985	4[1]	10.3	0.5	5.1	6	0.16	1.1	0.1
R. Sondu-Miriu	Savannah	3,470	45[3]	7.8	0.3	3.9	29	0.09	10.1	0.4
R. Gucha	Highland forest	6,600	66[3]	23.6	2.1	8.8	69	0.60	45.3	4.0
R. Kibuon	Highland forest	760	6[3]	10.5	0.7	6.8	25	0.21	1.9	0.1
R. Simiyu	Savannah	5,320	30[5]	11.8	0.3	2.8	196	0.10	104.1	2.9
R. Kagera	Highland forest	60,000	184[4]	23.9	0.4	1.6	213	0.11	1280.6	20.1
R. Mara	Savannah	13,504	35[2]	9.7	0.2	2.3	7	0.07	9.9	0.2
R. Nile at Jinia	Lake Victoria	238,900	981[6]	8.1	0.1	1.1	119	0.03	2303.1	25.6

[1](Sangale et al., 2012)· [2](Mutie et al., 2006), [3](Okungu and Opango, 2012), [4](FAO, 2014), [5](Rwetabula et al., 2007), [6](Ahmed and Ismail, 2008)

PyC movement in comparison to non-PyC movement

Our conclusion is that PyC was not preferentially transported in comparison to non-PyC in contrast to reports from plot-studies by Rumpel et al. (2006b), from headwater studies by Guggenberger et al. (2008), and from large watersheds by Jaffe et al. (2013). Assuming preferential erosion of PyC occurs, we would expect to see a depletion of PyC in the upper slope positions as a proportion of OC and corresponding enrichment in the lower slope positions over time. Our data indicate the opposite; there is an upslope enrichment of PyC to TOC in the surface soils with time. This could be explained by either a greater movement of non-PyC, but also a greater persistence of PyC to other forms of soil OC (Cheng et al., 2008; Liang et al., 2008) or a combination. As the natural levels of non-PyC C are mineralized to a greater degree than PyC after conversion to agriculture, the remaining stocks of PyC will increase in proportion. However, this landscape-scale distribution of PyC can not be explained by preferential movement of PyC.

Direct experimental evidence against preferential erosion of PyC at our sites is shown by the runoff data. Surficial water and OC flow could mainly be initiated with simulated rainfall events to exceed saturated conductivity in high-traffic turf, roads, and woodlots below the maximum rainfall intensity of 136 mm hr^{-1} found for the measurement period. Therefore, significant erosion of any OC may rarely occur in forests and crop fields. This lack of saturation excess runoff is typical for deep soils with high permeability (Mbagwu, 1997; Renck and Lehmann, 2004). When erosional events were induced with the infiltrometer and the sediments were captured, there were no significant increases in PyC concentration as a proportion of TOC over time in the runoff or in comparison to the soil contents that the OC originated from. This was true even in the forest plots where fresh PyC was added. The same conclusion can even be reached for the slightly larger scale of entire headwater catchments that did not show a relationship between PyC as a proportion of total C in stream water and topsoil.

Different deposition and therefore distribution above- and belowground may explain the differences in PyC and non-PyC export seen in our study as compared to other studies at similar scale (Rumpel et al*.,* 2006b; Guggenberger et al*.,* 2008). In natural forest fire deposition of PyC or in slash and burn events much of the above-ground non-PyC would be volatilized through burning or be converted to PyC. In this scenario PyC would be the dominant OC species deposited onto the soil surface and would therefore be the predominant OC form exposed to erosional forces. This is likely the scenario reported in Guggenberger et al. (2008) and in Rumpel et al. (2006b). Hence, rather than preferential erosion of PyC, a greater proportion of PyC export may be explained by the fact that the non-PyC stocks on the topsoil would be reduced due to the fire event, and PyC would be deposited on the topsoil or remain on remnants of vegetation (Schmidt, 2004) instead of incorporated into the soil. PyC would thereby erode preferentially by virtue of its location on or above the soil surface rather than for reasons of its material properties.

The lack of preferential erosion measured in our study even immediately after PyC deposition may possibly be explained by the incorporation of the PyC into the soil, as would occur during the land use change simulated here, which resembles "chop-and-char" rather than slash-and-burn. Since the relationships between the PyC fraction in eroded sediment as well as in stream water always remained below a 1:1 line regardless of site history, a lower movement of PyC than non-PyC may be explained by interactions of PyC with minerals (Brodowski et al*.,* 2006; Liang et al*.,* 2008) that could reduce mobility. These lines of evidence suggest that PyC was not preferentially eroded in comparison to non-PyC in the studied watersheds, but possibly retained to a greater extent.

In addition, the proportion of PyC to TOC leaving the Yala River into Lake Victoria (3.5%) is similar to the average value from the Kapchorwa catchments (3.8%), headwaters of the Yala River. These data suggest that the relationship between the export of PyC and TOC detailed in the Kapchorwa catchments is also the same when scaled across the entire Yala River catchment. When scaled across the entire Lake Victoria watershed, the magnitude of this relationship remains very similar (3.8% weighted average of all major rivers) despite large changes in the export stocks of TOC and PyC between the constituent river systems. This suggests that processes found at the Kapchorwa catchments may be typical for fire-prone East African landscapes.

Vertical redistribution of PyC within the catchments

Compared to the surface soils, PyC was significantly enriched with depth in the soil in comparison to non-PyC. In the surface soil the proportion of PyC to TOC ranged from 5 – 11%, when excluding the sites where charcoal production occurred. At 2 m within the soil profile, this concentration increased to between 9 – 13 % in the agricultural catchments and to between 22 – 24 % in the forest catchments. This suggests either a preferential movement of PyC down the soil profile (exceeding any direct deposition of non-PyC by plant roots) or greater persistence compared to non-PyC within deeper parts of the soil profile or during transport. Several studies have documented the downward movement of PyC in the soil profile (Brodowski et al., 2007; Leifeld et al., 2007a; Major et al., 2010). Leifeld et al. (2007b) and Dai et al. (2005) reported greater proportions of PyC as a fraction of TOC deeper in the soil profile. Leifeld et al. (2007b) suggested the high porosity of the studied peat soil and the often-saturated conditions at the site and therefore macropore flow as the likely mechanism for preferential PyC movement with depth. This mechanism is not probable in our catchments as the studied mineral soils have excellent drainage. Major et al. (2010) traced the fate of applied PyC over the course of two years and documented only 1% of applied PyC was leached below 0.3 m. Whether this movement will continue at this rate over time, is not known. Another potential mechanism is movement via bioturbation. In temperate environments earthworms are known to play an important role in soil OC cycling to depth. In tropical Africa termites are a major constituent of soil mesofauna and play a dominant role in the cycling of OC (Bignell et al., 1997; Jones, 1990). It is possible that termites are cycling OC from the surface of the soil to the deeper horizons. In the process the associated bacteria in the termites digestive system (Breznak, 2000) could be metabolizing the non-PyC and re-depositing the relatively persistent PyC, which would contribute to the enrichment.

Exports of PyC from the catchments

The concentrations of PyC as well as TOC in stream water base flow did not show any significant changes corresponding to the fluctuations in discharge throughout the year. This was true across all of the catchments as already shown by Recha et al. [2013] for DOC and particulate OC, despite differences in discharge between catchment land uses and catchment age. Base flow concentrations of solutes in stream water typically decreases during periods of high discharge through dilution (Johnson et al., 2006; Salmon et al., 2001). The lack of this dynamic even by PyC may indicate that it behaves similar as other non-PyC DOC in base flow. This is also supported by the correlation between PyC and non-PyC in stream and river waters during base flow. Since base flow comprised 70-80% of total streamflow in these watersheds (Recha et al., 2012), and since eroded sediment and DOC from infiltration experiments was not enriched in PyC over base flow (this study), this connection between non-PyC and PyC appears also to hold for total export including stormflow.

As the exports are calculated from base flow, the exported PyC has passed through the soil column, rather than exiting the catchment via overland flow. This is further supported by the significant correlation between PyC concentrations in the stream water to the PyC concentrations in the 1-2 m portion of the soil column. This suggests that a significant portion of PyC exported by streams during base flow is leaching through the soil over time. On the larger scale examined here through the rivers entering and leaving Lake Victoria, additional mobilization processes are likely at play. The 100-fold increases in TOC and PyC concentrations and exports per unit catchment size may suggest that either erosion is playing a larger role at larger scale, that losses from headwaters investigated at the headwaters are lower than from lower lying areas that are usually more densely populated, or that mobilization of bank sediments occurred during the rainy season. These spatial dynamics in upstream and downstream solute transport have been documented in previous studies of other large watersheds (Walling and Webb, 1980). The largely similar proportion of PyC of 1-10% of total C may suggest certain similarities in behavior across scales.

Conclusion

Our data suggest that the movement of PyC is not greater but even proportionally lower than that of non-PyC in the studied catchments. The magnitude of these losses is greatest within the first 10 years after initial deposition after which stabilization mechanisms reduce the losses. We estimate the yearly PyC export from the upper White Nile watershed of Lake Victoria to be around 26 Gg yr^{-1}. The data may imply that increases in the proportions of PyC in fluvial input to oceans documented in other papers are a result of either greater persistence during transport or lower retention in fluvial sediments. In addition, our data may also suggest that large-scale applications of anthropogenic PyC across similar landscapes not necessarily result in preferential transport losses of applied-PyC compared to other organic amendments. Further research is needed to verify that the results from this study are also found in other catchments at scale. In addition, intensive monitoring of catchment-scale experimental applications of PyC to the landscape over sequential years will elucidate contributions of mineralization and erosional losses of PyC over time.

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APPENDIX

Table 3.S1. Field saturated infiltrability across the Kapchorwa catchments measured by the Cornell Sprinkle Infiltrometers. Simulated rainfall rates of the infiltrometers was 300 mm hr^{-1}. Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, $P<0.05$, $n=8$). FB-PyC represents the researcher applied charcoal plots.

Catchment	Field-saturated infiltrability (mm hr^{-1})
Fa	168
Fa-CH	208
Fb	168
Fb-PyC	148
10a	210
10b	115
16a	77
16b	75
62a	97
62b	111
P-value	0.0432

Table 3.S2. Field saturated infiltrability across slope units within the Kapchorwa catchments measured by the Cornell Sprinkle Infiltrometers. Simulated rainfall rates of the infiltrometers was 300 mm hr^{-1}. Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, $P<0.05$, $n=8$). FB-PyC represents the researcher applied charcoal plots.

Catchment	Field-saturated infiltrability (mm hr^{-1})
CH	208 A
1% <	60 B
1-3%	108 AB
3-5%	118 AB
5-10%	148 AB
10-20%	83 AB
20-30%	159 AB
30% >	108 AB
P-value	0.0130

Table 3.S3. Field saturated infiltrability by land-use within the Kapchorwa catchments measured by the Cornell Sprinkle Infiltrometers. Simulated rainfall rates of the infiltrometers was 300 mm hr^{-1}. Different letters indicate significant differences, no letters are shown when main effect is not significant (Tukey's HSD, $P<0.05$, $n=8$). FB-PyC represents the researcher applied charcoal plots.

Land use	Field-saturated infiltrability (mm hr^{-1})
Beans	222 ABC
Sweet potato	222 ABC
Sugarcane	186 ABC
Forest	172 A
Ploughed bare fields	171 ABC
Napier grass	154 ABC
Maize	153 AB
Unploughed soil	150 ABC
Fallow	110 ABC
Tea	102 ABC
Homestead – bare soil	72 ABC
Kale	63 ABC
Eucalyptus	52 BC
Playground –bare	39 ABC
Pasture	39 C
Road	22 BC
Riverine vegetation	21 C
Arrow root	6 ABC
Homestead – grass	6 ABC
Playground - grass	6 ABC
P-value	<0.0001

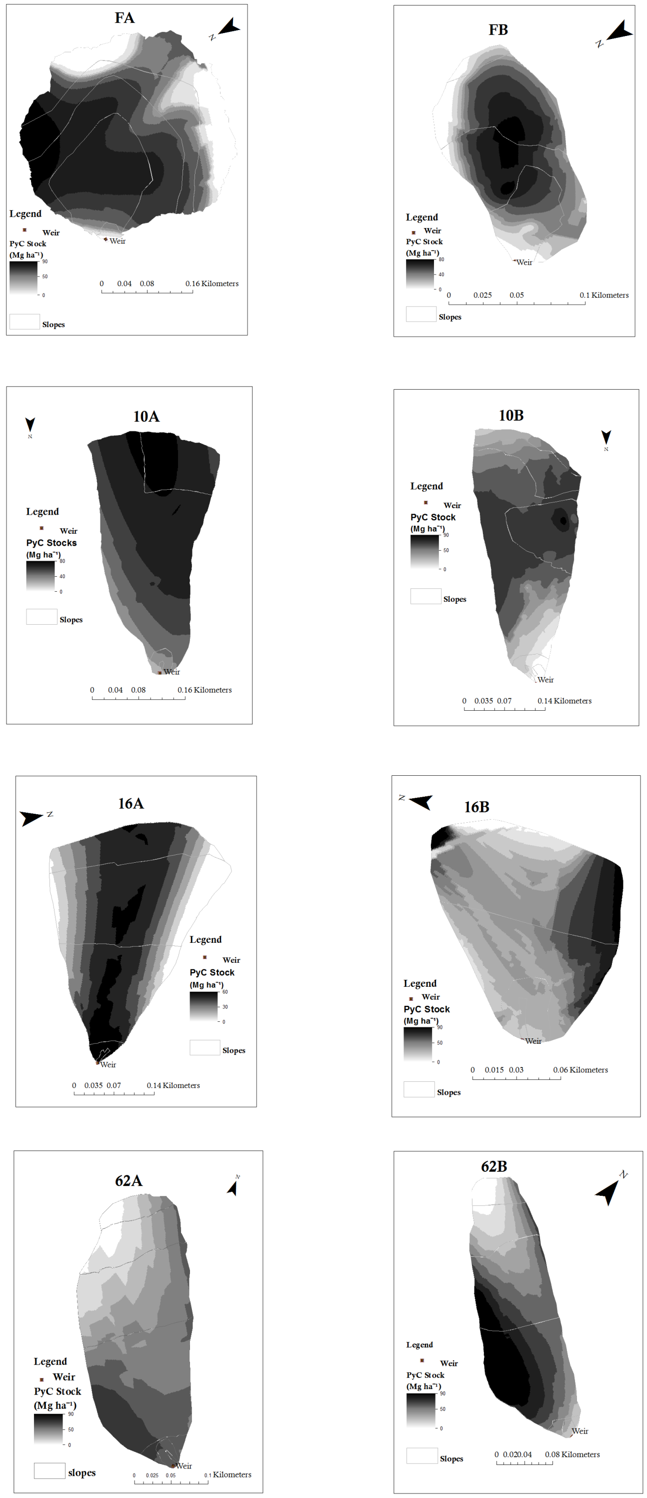

Figure 3.S1. Kriging map of the distribution of soil PyC stocks in the Kapchorwa catchments. All catchments are oriented with the weir at the bottom of each map.

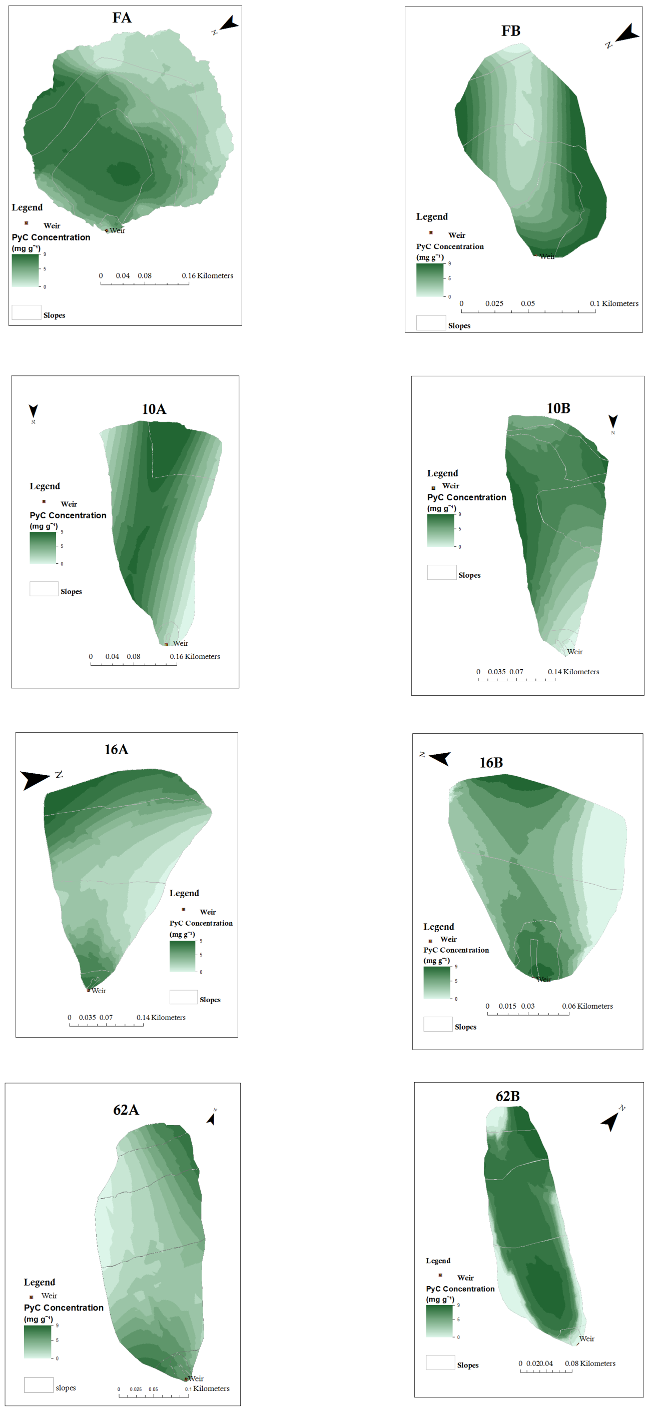

Figure 3.S2. Kriging map of the distribution of soil PyC concentrations in the Kapchorwa catchments. All catchments are oriented with the weir at the bottom of each map.

Table 3.S4. Data from chapter 1 tables 1.2 and 1.3.

FEEDSTOCK	TEMP (°C)	TREATMENT	REP	NO. OF NODULES	Nodules Dry-Weight (g)	SHOOT DRY WEIGHT (g)	ROOTS DRY WEIGHT (g)
Rice	350	None	1	76	0.108	1.53	0.62
Rice	350	None	2	146	0.1727	1.97	0.26
Rice	350	None	3	148	0.0901	1.16	0.46
Rice	350	None	4	162	0.1584	1.68	0.48
Rice	550	None	1	160	0.1522	2.05	0.44
Rice	550	None	2	165	0.1867	2.67	0.57
Rice	550	None	3	142	0.2303	2.85	0.26
Rice	550	None	4	77	0.1122	1.16	0.66
Rice	350	Acetone	1	130	0.1845	2.07	0.65
Rice	350	Acetone	2	90	0.0657	1.1	0.52
Rice	350	Acetone	3	159	0.2016	2.7	0.41
Rice	350	Acetone	4	226	0.1475	1.02	0.34
Rice	550	Acetone	1	186	0.206	2.52	0.51
Rice	550	Acetone	2	123	0.1076	2.11	0.4
Rice	550	Acetone	3				
Rice	550	Acetone	4	205	0.2187	2.35	0.44
Rice	350	H_2O	1	212	0.181	2.3	0.5
Rice	350	H_2O	2	139	0.1744	2.36	0.68
Rice	350	H_2O	3	135	0.1309	1.74	0.7
Rice	350	H_2O	4	202	0.2867	2.6	0.41
Rice	550	H_2O	1	163	0.1877	2.08	0.46
Rice	550	H_2O	2	162	0.1448	2.02	0.65
Rice	550	H_2O	3	110	0.1416	1.86	0.25
Rice	550	H_2O	4	166	0.1907	2.9	0.84
Rice	350	HCL	1	70	0.0709	1.7	0.47
Rice	350	HCL	2	197	0.19	2.79	0.54
Rice	350	HCL	3	100	0.0934	1.61	0.49
Rice	350	HCL	4	147	0.1979	2.68	0.38
Rice	550	HCL	1	182	0.1888	1.82	0.56
Rice	550	HCL	2	85	0.0761	2	0.35
Rice	550	HCL	3	162	0.1305	1.99	0.67
Rice	550	HCL	4	82	0.135	2.54	0.63
Bagasse	350	None	1	90	0.0937	1.58	0.44
Bagasse	350	None	2	192	0.1721	2.19	0.74
Bagasse	350	None	3	209	0.2096	2.49	0.6

Bagasse	350	None	4	136	0.1812	2.25	0.5
Bagasse	550	None	1	112	0.1569	1.82	0.38
Bagasse	550	None	2	100	0.112	1.68	0.26
Bagasse	550	None	3	105	0.2174	2.62	0.43
Bagasse	550	None	4	46	0.0229	0.74	0.4
Bagasse	350	Acetone	1	186	0.1787	1.96	0.53
Bagasse	350	Acetone	2	90	0.117	1.1	0.62
Bagasse	350	Acetone	3	196	0.2053	2.36	0.28
Bagasse	350	Acetone	4	195	0.1584	2.25	0.54
Bagasse	550	Acetone	1	163	0.2408	2.63	0.83
Bagasse	550	Acetone	2	174	0.2219	2.36	0.62
Bagasse	550	Acetone	3	100	0.0976	1.41	0.29
Bagasse	550	Acetone	4	249	0.2509	2.54	0.62
Bagasse	350	H_2O	1	181	0.1781	1.81	0.57
Bagasse	350	H_2O	2	120	0.1485	1.44	0.49
Bagasse	350	H_2O	3	82	0.1315	1.6	0.28
Bagasse	350	H_2O	4	106	0.1123	2	0.44
Bagasse	550	H_2O	1	192	0.1256	1.18	0.29
Bagasse	550	H_2O	2	189	0.1506	1.36	0.56
Bagasse	550	H_2O	3	237	0.209	3	0.49
Bagasse	550	H_2O	4	149	0.2255	2.5	0.49
Bagasse	350	HCL	1	182	0.1233	2.05	0.57
Bagasse	350	HCL	2	48	0.0115	0.83	0.34
Bagasse	350	HCL	3	144	0.1544	2.37	0.6
Bagasse	350	HCL	4	116	0.05113	2.19	0.55
Bagasse	550	HCL	1	47	0.015	0.93	0.35
Bagasse	550	HCL	2	100	0.19092	0.96	0.58
Bagasse	550	HCL	3	87	0.0459	1.42	0.45
Bagasse	550	HCL	4	187	0.1838	1.66	0.25
Maize stovers	350	None	1	42	0.0538	1.31	0.28
Maize stovers	350	None	2	111	0.1447	1.83	0.33
Maize stovers	350	None	3	91	0.1223	1.93	0.64
Maize stovers	350	None	4	95	0.109	1.48	0.47
Maize stovers	550	None	1	58	0.0644		0.39
Maize stovers	550	None	2	82	0.0681	0.81	0.56
Maize stovers	550	None	3	101	0.0846	1.55	0.48
Maize stovers	550	None	4	88	0.0527	0.98	0.34
Maize stovers	350	Acetone	1	155	0.1703	1.77	0.57
Maize stovers	350	Acetone	2	162	0.2174	2.22	0.57
Maize stovers	350	Acetone	3	202	0.2692	2.22	0.75
Maize stovers	350	Acetone	4	169	0.1722	1.98	0.56

Maize stovers	550	Acetone	1	221	0.1718	1.63	0.52
Maize stovers	550	Acetone	2	188	0.1933	1.99	0.36
Maize stovers	550	Acetone	3	77	0.0693	0.8	0.48
Maize stovers	550	Acetone	4	237	0.2226	3.12	0.65
Maize stovers	350	H_2O	1	122	0.1605	2.09	0.71
Maize stovers	350	H_2O	2	78	0.0238	1.48	0.9
Maize stovers	350	H_2O	3	83	0.1238	1.9	0.53
Maize stovers	350	H_2O	4				
Maize stovers	550	H_2O	1	91	0.0689	1.66	0.65
Maize stovers	550	H_2O	2	80	0.0496	0.9	0.4
Maize stovers	550	H_2O	3	105	0.1278	1.96	0.5
Maize stovers	550	H_2O	4	152	0.1245	1.38	0.3
Maize stovers	350	HCL	1	20	0.0033	1.32	0.44
Maize stovers	350	HCL	2	31	0.0062	1.64	0.25
Maize stovers	350	HCL	3	65	0.0422	1.76	0.33
Maize stovers	350	HCL	4	53	0.0244	1.97	0.38
Maize stovers	550	HCL	1	163	0.1346	2.11	0.56
Maize stovers	550	HCL	2	301	0.2457	2.1	0.61
Maize stovers	550	HCL	3	113	0.1041	1.7	0.32
Maize stovers	550	HCL	4	59	0.0533	1.17	0.45
Maize cobs	350	None	1	100	0.1222	1.64	0.45
Maize cobs	350	None	2	133	0.1549	2.63	0.64
Maize cobs	350	None	3	26	0.0072	1.59	0.51
Maize cobs	350	None	4	55	0.0235	0.75	0.33
Maize cobs	550	None	1	102	0.1359	1.45	0.3
Maize cobs	550	None	2	100	0.1567	1.61	0.4
Maize cobs	550	None	3	67	0.0823	1.69	0.47
Maize cobs	550	None	4			1.57	
Maize cobs	350	Acetone	1	125	0.1938	2.1	0.44
Maize cobs	350	Acetone	2	76	0.0707	1.34	0.4
Maize cobs	350	Acetone	3	159	0.1908	1.8	0.2
Maize cobs	350	Acetone	4	132	0.1908	2.34	0.29
Maize cobs	550	Acetone	1	174	0.2238	2.52	0.3
Maize cobs	550	Acetone	2				
Maize cobs	550	Acetone	3	141	0.1579	2.05	0.39
Maize cobs	550	Acetone	4	215	0.198	2.35	0.46
Maize cobs	350	H_2O	1	165	0.1309	2.01	0.31
Maize cobs	350	H_2O	2	14	0.0068	1.56	0.34
Maize cobs	350	H_2O	3	154	0.1872	1.75	0.32
Maize cobs	350	H_2O	4	96	0.0938	0.31	0.49

Maize cobs	550	H_2O	1	91	0.1152	1.31	0.62
Maize cobs	550	H_2O	2	75	0.1205	1.64	0.43
Maize cobs	550	H_2O	3	19	0.0022	1.23	0.32
Maize cobs	550	H_2O	4	208	0.3079	2.5	0.49
Maize cobs	350	HCL	1	105	0.1318	2.09	0.61
Maize cobs	350	HCL	2	94	0.0563	1.83	0.45
Maize cobs	350	HCL	3	85	0.0901	1.74	0.52
Maize cobs	350	HCL	4	69	0.04723	1.52	0.59
Maize cobs	550	HCL	1	147	0.1054	1.27	0.6
Maize cobs	550	HCL	2	63	0.0537	1.56	0.57
Maize cobs	550	HCL	3	104	0.1376	1.74	0.48
Maize cobs	550	HCL	4	42	0.01827	1.16	0.41
Eucalyptus	350	None	1	156	0.147	1.69	0.39
Eucalyptus	350	None	2	241	0.2283	2.7	0.39
Eucalyptus	350	None	3	172	0.2089	2.2	0.26
Eucalyptus	350	None	4	131	0.1129	1.79	0.29
Eucalyptus	550	None	1	208	0.1496	1.97	0.48
Eucalyptus	550	None	2	24	0.0394	1.59	0.32
Eucalyptus	550	None	3	165	0.1185	1.87	0.3
Eucalyptus	550	None	4	174	0.1755	2.51	0.31
Eucalyptus	350	Acetone	1	189	0.1372	1.74	0.24
Eucalyptus	350	Acetone	2	146	0.155	2.65	0.42
Eucalyptus	350	Acetone	3	160	0.1445	1.74	0.18
Eucalyptus	350	Acetone	4	181	0.1776	2.64	0.41
Eucalyptus	550	Acetone	1	113	0.0933	0.93	0.29
Eucalyptus	550	Acetone	2	158	0.1196	0.97	0.13
Eucalyptus	550	Acetone	3	325	0.02044	1.71	0.31
Eucalyptus	550	Acetone	4	138	0.1167	0.8	0.43
Eucalyptus	350	H_2O	1	21	0.0105	1.27	0.49
Eucalyptus	350	H_2O	2	77	0.0503	1.86	0.44
Eucalyptus	350	H_2O	3	64	0.077	2.91	0.45
Eucalyptus	350	H_2O	4	124	0.1076	1.81	0.42
Eucalyptus	550	H_2O	1	104	0.0609	1.22	0.29
Eucalyptus	550	H_2O	2	6	0.0004	0.85	0.36
Eucalyptus	550	H_2O	3	38	0.0226	0.46	0.34
Eucalyptus	550	H_2O	4	134	0.1364	1.8	0.47
Eucalyptus	350	HCL	1	233	0.1184	1.94	0.45
Eucalyptus	350	HCL	2	145	0.1208	1.68	0.52
Eucalyptus	350	HCL	3	195	0.1717	1.9	0.92
Eucalyptus	350	HCL	4	124	0.0995	1.9	0.51

Eucalyptus	550	HCL	1	17	0.028	1.32	0.34
Eucalyptus	550	HCL	2	124	0.0836	2.07	0.3
Eucalyptus	550	HCL	3	58	0.0232	1.23	0.38
Eucalyptus	550	HCL	4	202	0.1305	1.8	0.29
Delonix	350	None	1	7	0.028	0.75	0.42
Delonix	350	None	2	169	0.2671	2.64	0.21
Delonix	350	None	3	126	0.1176	1.86	0.6
Delonix	350	None	4	138	0.1338	2.02	0.16
Delonix	550	None	1	284	0.2118	1.93	0.4
Delonix	550	None	2	180	0.2268	2.41	0.43
Delonix	550	None	3	136	0.1591	2.23	0.25
Delonix	550	None	4	266	0.2237	2.25	0.41
Delonix	350	Acetone	1	34	0.0078	0.4	0.12
Delonix	350	Acetone	2	106	0.0902	1.3	0.68
Delonix	350	Acetone	3	180	0.1376	2.29	0.57
Delonix	350	Acetone	4	216	0.2128	2.44	0.78
Delonix	550	Acetone	1	245	0.3222	3.05	0.58
Delonix	550	Acetone	2	209	0.2155	2.8	0.46
Delonix	550	Acetone	3	235	0.1925	1.62	0.64
Delonix	550	Acetone	4	316	0.2816	2.62	0.36
Delonix	350	H_2O	1	215	0.276	2.7	0.21
Delonix	350	H_2O	2	142	0.1724	1.6	0.76
Delonix	350	H_2O	3	279	0.2211	2.2	0.58
Delonix	350	H_2O	4	108	0.1578	2.95	0.53
Delonix	550	H_2O	1	136	0.1254	2.5	0.6
Delonix	550	H_2O	2	260	0.1767	1.64	0.64
Delonix	550	H_2O	3	175	0.1506	1.36	0.54
Delonix	550	H_2O	4			Died	0.36
Delonix	350	HCL	1	127	0.1	1.9	0.5
Delonix	350	HCL	2	83	0.0768	1.49	0.65
Delonix	350	HCL	3	124	0.0812	1.75	0.43
Delonix	350	HCL	4	145	0.1724	1.83	0.52
Delonix	550	HCL	1	107	0.786	1.77	0.38
Delonix	550	HCL	2	237	0.1393	2.81	0.43
Delonix	550	HCL	3				
Delonix	550	HCL	4	179	0.116	1.98	0.39
Tea	350	None	1	167	0.1655	1.96	0.6
Tea	350	None	2	116	0.1576	2.41	0.45
Tea	350	None	3	207	0.2449	3.43	0.74
Tea	350	None	4	68	0.0997	1.64	0.41
Tea	550	None	1	174	0.159	1.62	0.49

Tea	550	None	2	265	0.1335	1.45	0.11
Tea	550	None	3	207	0.2285	1.9	0.41
Tea	550	None	4	259	0.2633	2.75	0.5
Tea	350	Acetone	1	220	0.2071	1.47	0.2
Tea	350	Acetone	2	82	0.0886	1.66	0.46
Tea	350	Acetone	3	173	0.1965	2.46	0.49
Tea	350	Acetone	4	230	0.2753	2.71	0.45
Tea	550	Acetone	1	249	0.1432	1.38	0.46
Tea	550	Acetone	2	156	0.1359	2.03	0.48
Tea	550	Acetone	3	282	0.2113	1.86	0.36
Tea	550	Acetone	4	225	0.2358	2.17	0.42
Tea	350	H_2O	1	217	0.2476	2.32	0.56
Tea	350	H_2O	2				
Tea	350	H_2O	3	254	0.3116	0.83	0.7
Tea	350	H_2O	4	186	0.2124	1.87	0.51
Tea	550	H_2O	1	177	0.128	1.77	0.24
Tea	550	H_2O	2	170	0.1034	0.82	0.18
Tea	550	H_2O	3	188	0.1652	2.62	0.22
Tea	550	H_2O	4	105	0.1095	1.48	0.17
Tea	350	HCL	1	108	0.1139	1.67	0.46
Tea	350	HCL	2	136	0.1251	1.3	
Tea	350	HCL	3	139	0.094	1.71	0.32
Tea	350	HCL	4	85	0.0992	1.27	0.43
Tea	550	HCL	1	202	0.1276	1.71	0.21
Tea	550	HCL	2	175	0.6941	1.97	0.49
Tea	550	HCL	3	392	0.1773	1.8	0.49
Tea	550	HCL	4	133	0.0939	1.71	0.5
Control	0	Control	1	42	0.0021	0.65	0.28
Control	0	Control	2	8	0.0006	0.38	0.31
Control	0	Control	3				
Control	0	Control	4	16	0.009	1.11	0.26

Table 3.S5. Data from chapter 1 table and 1.3.

Feedstock	Temp (^oC)	Treatment	Rep	Ndfa (%)	Ndfa (mg g^{-1})
Rice	350	None	1	39.25	0.02
Rice	350	None	2	51.61	0.02
Rice	350	None	3	32.74	0.01
Rice	350	None	4	49.25	0.02
Rice	550	None	1	57.58	0.02
Rice	550	None	2	54.11	0.02
Rice	550	None	3	63.77	0.02
Rice	550	None	4	37.28	0.01
Rice	350	Acetone	1	53.61	0.02
Rice	350	Acetone	2	21.90	0.01
Rice	350	Acetone	3	66.27	0.02
Rice	350	Acetone	4	49.47	0.02
Rice	550	Acetone	1	64.36	0.03
Rice	550	Acetone	2	53.96	0.02
Rice	550	Acetone	3		
Rice	550	Acetone	4	52.80	0.02
Rice	350	H_2O	1	55.28	0.02
Rice	350	H_2O	2	43.74	0.02
Rice	350	H_2O	3	20.71	0.01
Rice	350	H_2O	4	43.58	0.02
Rice	550	H_2O	1	41.44	0.01
Rice	550	H_2O	2	41.72	0.01
Rice	550	H_2O	3	37.06	0.01
Rice	550	H_2O	4	47.15	0.01
Rice	350	HCL	1	25.13	0.01
Rice	350	HCL	2	56.86	0.02
Rice	350	HCL	3	21.27	0.01
Rice	350	HCL	4	54.38	0.01
Rice	550	HCL	1	48.31	0.01
Rice	550	HCL	2	25.63	0.01
Rice	550	HCL	3	42.95	0.01
Rice	550	HCL	4	56.51	0.01
Bagasse	350	None	1	26.09	0.01
Bagasse	350	None	2	52.59	0.01
Bagasse	350	None	3	35.01	0.01
Bagasse	350	None	4	64.85	0.02
Bagasse	550	None	1	45.64	0.02

Bagasse	550	None	2	41.55	0.01
Bagasse	550	None	3	51.15	0.01
Bagasse	550	None	4	7.17	0.00
Bagasse	350	Acetone	1	50.09	0.02
Bagasse	350	Acetone	2	26.57	0.01
Bagasse	350	Acetone	3	61.98	0.02
Bagasse	350	Acetone	4	52.81	0.02
Bagasse	550	Acetone	1	60.64	0.02
Bagasse	550	Acetone	2	55.67	0.02
Bagasse	550	Acetone	3	43.83	0.02
Bagasse	550	Acetone	4	60.04	0.02
Bagasse	350	H_2O	1	34.73	0.01
Bagasse	350	H_2O	2	41.15	0.02
Bagasse	350	H_2O	3	37.12	0.01
Bagasse	350	H_2O	4	38.95	0.01
Bagasse	550	H_2O	1	55.01	0.01
Bagasse	550	H_2O	2	56.90	0.02
Bagasse	550	H_2O	3	66.03	0.02
Bagasse	550	H_2O	4	49.46	0.02
Bagasse	350	HCL	1	28.64	0.01
Bagasse	350	HCL	2	5.07	0.00
Bagasse	350	HCL	3	8.28	0.00
Bagasse	350	HCL	4	10.64	0.00
Bagasse	550	HCL	1	15.98	0.00
Bagasse	550	HCL	2	36.25	0.01
Bagasse	550	HCL	3	34.77	0.01
Bagasse	550	HCL	4	43.86	0.02
Maize stovers	350	None	1	28.23	0.01
Maize stovers	350	None	2	33.17	0.01
Maize stovers	350	None	3	33.83	0.01
Maize stovers	350	None	4	30.88	0.01
Maize stovers	550	None	1		
Maize stovers	550	None	2	27.95	0.01
Maize stovers	550	None	3	24.98	0.01
Maize stovers	550	None	4	27.94	0.01
Maize stovers	350	Acetone	1	42.60	0.01

Maize stovers	350	Acetone	2	45.16	0.02
Maize stovers	350	Acetone	3	60.68	0.03
Maize stovers	350	Acetone	4	47.03	0.02
Maize stovers	550	Acetone	1	59.70	0.02
Maize stovers	550	Acetone	2	69.17	0.02
Maize stovers	550	Acetone	3	47.94	0.01
Maize stovers	550	Acetone	4	60.45	0.02
Maize stovers	350	H_2O	1	-7.53	0.00
Maize stovers	350	H_2O	2	11.17	0.00
Maize stovers	350	H_2O	3	-11.72	0.00
Maize stovers	350	H_2O	4		
Maize stovers	550	H_2O	1	22.03	0.01
Maize stovers	550	H_2O	2	21.15	0.01
Maize stovers	550	H_2O	3	42.80	0.01
Maize stovers	550	H_2O	4	50.82	0.02
Maize stovers	350	HCL	1	1.67	0.00
Maize stovers	350	HCL	2	-7.94	0.00
Maize stovers	350	HCL	3	4.36	0.00
Maize stovers	350	HCL	4	-3.26	0.00
Maize stovers	550	HCL	1	25.98	0.01
Maize stovers	550	HCL	2	44.77	0.01
Maize stovers	550	HCL	3	25.25	0.01
Maize stovers	550	HCL	4	11.88	0.00
Maize cobs	350	None	1	32.95	0.01
Maize cobs	350	None	2	-5.22	0.00
Maize cobs	350	None	3	2.40	0.00
Maize cobs	350	None	4	36.83	0.01
Maize cobs	550	None	1	39.70	0.01
Maize cobs	550	None	2	24.88	0.01

Maize cobs	550	None	3	50.53	0.02
Maize cobs	550	None	4		
Maize cobs	350	Acetone	1	60.74	0.02
Maize cobs	350	Acetone	2	36.75	0.01
Maize cobs	350	Acetone	3	62.02	0.02
Maize cobs	350	Acetone	4	64.35	0.02
Maize cobs	550	Acetone	1	54.60	0.01
Maize cobs	550	Acetone	2		
Maize cobs	550	Acetone	3	57.17	0.02
Maize cobs	550	Acetone	4	13.46	0.00
Maize cobs	350	H_2O	1	45.43	0.01
Maize cobs	350	H_2O	2	4.15	0.00
Maize cobs	350	H_2O	3	41.24	0.01
Maize cobs	350	H_2O	4	32.10	0.01
Maize cobs	550	H_2O	1	38.54	0.02
Maize cobs	550	H_2O	2	-16.19	0.00
Maize cobs	550	H_2O	3	49.40	0.02
Maize cobs	550	H_2O	4	26.05	0.01
Maize cobs	350	HCL	1	12.57	0.00
Maize cobs	350	HCL	2	25.58	0.01
Maize cobs	350	HCL	3	15.67	0.01
Maize cobs	350	HCL	4	34.47	0.01
Maize cobs	550	HCL	1	16.20	0.01
Maize cobs	550	HCL	2	32.00	0.01
Maize cobs	550	HCL	3	18.07	0.00
Maize cobs	550	HCL	4	21.11	0.01
Eucalyptus	350	None	1	28.20	0.01
Eucalyptus	350	None	2	39.47	0.01
Eucalyptus	350	None	3	39.22	0.01
Eucalyptus	350	None	4	32.80	0.01
Eucalyptus	550	None	1	43.40	0.02
Eucalyptus	550	None	2	46.53	0.01
Eucalyptus	550	None	3	39.25	0.02
Eucalyptus	550	None	4	62.63	0.02
Eucalyptus	350	Acetone	1	19.29	0.01
Eucalyptus	350	Acetone	2	50.78	0.01
Eucalyptus	350	Acetone	3	32.40	0.01
Eucalyptus	350	Acetone	4	49.41	0.01
Eucalyptus	550	Acetone	1	52.21	0.02
Eucalyptus	550	Acetone	2	59.75	0.02
Eucalyptus	550	Acetone	3	67.68	0.02

Eucalyptus	550	Acetone	4	54.05	0.02
Eucalyptus	350	H_2O	1	6.63	0.00
Eucalyptus	350	H_2O	2	5.04	0.00
Eucalyptus	350	H_2O	3	42.56	0.01
Eucalyptus	350	H_2O	4	17.13	0.00
Eucalyptus	550	H_2O	1	22.79	0.01
Eucalyptus	550	H_2O	2	-4.24	0.00
Eucalyptus	550	H_2O	3	-2.29	0.00
Eucalyptus	550	H_2O	4	10.87	0.00
Eucalyptus	350	HCL	1	13.26	0.00
Eucalyptus	350	HCL	2	20.15	0.00
Eucalyptus	350	HCL	3	30.64	0.01
Eucalyptus	350	HCL	4	23.46	0.01
Eucalyptus	550	HCL	1	14.11	0.00
Eucalyptus	550	HCL	2	21.42	0.00
Eucalyptus	550	HCL	3	-0.45	0.00
Eucalyptus	550	HCL	4	24.47	0.01
Delonix	350	None	1	9.30	0.00
Delonix	350	None	2	42.23	0.01
Delonix	350	None	3	17.43	0.01
Delonix	350	None	4	23.08	0.01
Delonix	550	None	1	47.85	0.02
Delonix	550	None	2	50.53	0.02
Delonix	550	None	3	51.68	0.02
Delonix	550	None	4	51.14	0.02
Delonix	350	Acetone	1	0.52	0.00
Delonix	350	Acetone	2	16.38	0.00
Delonix	350	Acetone	3	28.57	0.01
Delonix	350	Acetone	4	38.94	0.01
Delonix	550	Acetone	1	52.39	0.01
Delonix	550	Acetone	2	55.80	0.02
Delonix	550	Acetone	3	50.91	0.02
Delonix	550	Acetone	4	49.61	0.02
Delonix	350	H_2O	1	31.53	0.01
Delonix	350	H_2O	2	35.97	0.02
Delonix	350	H_2O	3	41.85	0.01
Delonix	350	H_2O	4	27.42	0.01
Delonix	550	H_2O	1	37.37	0.02
Delonix	550	H_2O	2	49.18	0.01
Delonix	550	H_2O	3	31.50	0.01

Delonix	550	H_2O	4		
Delonix	350	HCL	1	21.62	0.01
Delonix	350	HCL	2	6.67	0.00
Delonix	350	HCL	3	11.47	0.00
Delonix	350	HCL	4	25.14	0.01
Delonix	550	HCL	1	43.63	0.01
Delonix	550	HCL	2	35.78	0.01
Delonix	550	HCL	3		
Delonix	550	HCL	4	42.62	0.02
Tea	350	None	1	50.31	0.01
Tea	350	None	2	48.15	0.01
Tea	350	None	3	44.88	0.01
Tea	350	None	4	32.25	0.01
Tea	550	None	1	47.61	0.01
Tea	550	None	2		
Tea	550	None	3	55.51	0.02
Tea	550	None	4	54.13	0.02
Tea	350	Acetone	1	58.26	0.02
Tea	350	Acetone	2	38.53	0.01
Tea	350	Acetone	3	48.31	0.01
Tea	350	Acetone	4	64.57	0.02
Tea	550	Acetone	1	51.12	0.02
Tea	550	Acetone	2	40.96	0.01
Tea	550	Acetone	3	50.68	0.02
Tea	550	Acetone	4	52.54	0.02
Tea	350	H_2O	1	39.41	0.01
Tea	350	H_2O	2		
Tea	350	H_2O	3	52.44	0.01
Tea	350	H_2O	4	35.43	0.01
Tea	550	H_2O	1	43.15	0.01
Tea	550	H_2O	2	32.66	0.01
Tea	550	H_2O	3	50.39	0.02
Tea	550	H_2O	4	49.96	0.02
Tea	350	HCL	1	23.08	0.01
Tea	350	HCL	2	24.13	0.01
Tea	350	HCL	3	15.02	0.00
Tea	350	HCL	4	8.86	0.00
Tea	550	HCL	1	49.26	0.01
Tea	550	HCL	2	42.51	0.01
Tea	550	HCL	3	45.44	0.01
Tea	550	HCL	4	45.79	0.01

Control	0	Control	1	1.90	0.00
Control	0	Control	2	1.99	0.00
Control	0	Control	3		
Control	0	Control	4	5.52	0.00

Table 3.S6. Data from chapter 1 table 1.4.

Feedstocl	Temp (°C)	Treatment	Rep	P (mg g^{-1})	P (mg plant^{-1})	Na (mg g^{-1})	Na (mg plant^{-1})	Mg (mg g^{-1})	Mg (mg plant^{-1})
Rice	350	None	1	0.00	0.01	11.42	17.47	354.85	542.91
Rice	350	None	2	0.00	0.01	8.63	17.00	246.48	485.56
Rice	350	None	3	0.00	0.00	12.26	14.22	354.46	411.17
Rice	350	None	4	0.00	0.01	35.61	59.83	233.24	391.85
Rice	550	None	1	0.00	0.00	15.03	30.81	327.26	670.89
Rice	550	None	2	0.00	0.01	9.11	24.31	247.91	661.93
Rice	550	None	3	0.00	0.00	9.90	28.21	227.88	649.47
Rice	550	None	4	0.00	0.00	24.40	28.30	515.03	597.43
Rice	350	Acetone	1	0.00	0.01	7.43	15.39	193.06	399.64
Rice	350	Acetone	2	0.00	0.00	17.95	19.75	527.00	579.70
Rice	350	Acetone	3	0.00	0.01	7.67	20.72	149.72	404.23
Rice	350	Acetone	4	0.00	0.00	25.08	25.58	341.52	348.35
Rice	550	Acetone	1	0.00	0.00	18.31	46.13	288.08	725.96
Rice	550	Acetone	2	0.00	0.00	27.93	58.94	256.96	542.18
Rice	550	Acetone	3						
Rice	550	Acetone	4	0.00	0.00	24.84	58.37	254.62	598.37
Rice	350	H_2O	1	0.00	0.01	5.63	12.95	162.43	373.59
Rice	350	H_2O	2	0.00	0.00	15.06	35.55	232.56	548.85
Rice	350	H_2O	3	0.00	0.00	9.88	17.18	242.54	422.02
Rice	350	H_2O	4	0.00	0.01	9.88	25.69	182.97	475.71
Rice	550	H_2O	1	0.00	0.00	19.89	41.38	296.80	617.34
Rice	550	H_2O	2	0.00	0.00	13.68	27.63	233.17	471.01
Rice	550	H_2O	3	0.00	0.00	15.13	28.14	257.29	478.55
Rice	550	H_2O	4	0.00	0.00	8.18	23.73	174.35	505.60
Rice	350	HCL	1	0.00	0.00	16.32	27.75	309.63	526.37
Rice	350	HCL	2	0.00	0.01	6.92	19.31	148.50	414.31
Rice	350	HCL	3	0.00	0.00	23.76	38.26	351.96	566.66
Rice	350	HCL	4	0.00	0.00	12.28	32.91	249.89	669.70
Rice	550	HCL	1	0.00	0.00	15.12	27.52	339.57	618.01
Rice	550	HCL	1	0.00	0.00	19.30	35.12	335.97	611.46
Rice	550	HCL	2	0.00	0.00	22.30	44.59	292.45	584.91
Rice	550	HCL	3	0.00	0.00	18.73	37.27	344.41	685.37

Rice	550	HCL	4	0.00	0.00	11.24	28.54	247.89	629.64
Rice	350	None	1	0.00	0.00	14.13	32.35	229.49	525.52
Rice	350	None	2	0.00	0.00	7.88	19.07	238.90	578.15
Rice	350	None	3	0.00	0.00	8.86	20.99	170.53	404.15
Rice	350	None	4	0.00	0.00	8.79	23.90	199.94	543.85
Rice	550	None	1	0.00	0.00	11.26	26.68	355.33	842.14
Rice	550	None	2	0.00	0.00	12.26	16.43	703.46	942.64
Rice	550	None	3	0.00	0.00	0.07	0.16	307.51	713.42
Rice	550	None	4						
Rice	350	Acetone	1	0.00	0.00	0.77	1.31	354.01	601.81
Rice	350	Acetone	2	0.00	0.00	3.00	6.13	267.83	546.38
Rice	350	Acetone	3	0.00	0.00	0.00	0.00	277.85	497.36
Rice	350	Acetone	4	0.00	0.00	1.03	2.12	252.47	517.56
Rice	550	Acetone	1	0.00	0.00	0.00	0.00	738.98	768.54
Rice	550	Acetone	2	0.00	0.00	0.00	0.00	425.35	757.12
Rice	550	Acetone	3	0.00	0.00	0.20	0.45	292.22	648.74
Rice	550	Acetone	4	0.00	0.00	0.00	0.00	394.29	615.09
Rice	550	Acetone	4						
Rice	350	H_2O	1	0.00	0.00	0.00	0.00	623.86	1366.26
Rice	350	H_2O	2	0.00	0.00	0.00	0.00	208.31	477.03
Rice	350	H_2O	3	0.00	0.00	0.73	1.52	247.86	513.08
Rice	350	H_2O	4	0.00	0.01	0.00	0.00	192.46	483.08
Rice	550	H_2O	1	0.00	0.00	0.00	0.00	370.68	815.49
Rice	550	H_2O	2	0.00	0.00	0.00	0.00	242.82	602.20
Rice	550	H_2O	3	0.00	0.00	0.00	0.00	311.20	616.18
Rice	550	H_2O	4	0.00	0.00	0.00	0.00	437.12	690.64
Rice	350	HCL	1	0.00	0.01	0.00	0.00	154.99	376.63
Rice	350	HCL	2	0.00	0.01	2.61	7.79	2.37	7.09
Rice	350	HCL	3	0.00	0.01	1.82	4.48	2.18	5.37
Rice	350	HCL	4	0.00	0.00	4.34	3.26	7.61	5.70
Rice	550	HCL	1	0.00	0.00	6.47	9.05	11.10	15.54
Rice	550	HCL	2	0.00	0.00	7.16	8.02	5.59	6.26
Rice	550	HCL	3	0.00	0.01	1.52	3.90	2.51	6.42
Rice	550	HCL	4	0.00	0.01	1.28	3.45	2.14	5.75
Bagasse	350	None	1	0.00	0.01	1.33	2.09	3.14	4.96
Bagasse	350	None	2	0.01	0.01	0.97	2.12	1.53	3.35
Bagasse	350	None	3	0.01	0.02	0.59	1.48	1.11	2.75
Bagasse	350	None	4	0.01	0.01	0.65	1.46	1.48	3.34
Bagasse	550	None	1	0.01	0.01	1.15	2.09	1.46	2.67
Bagasse	550	None	2	0.01	0.01	0.66	1.10	1.47	2.47
Bagasse	550	None	3	0.00	0.01	0.39	1.02	0.93	2.44

Bagasse	550	None	4	0.00	0.00	1.10	0.81	6.50	4.81
Bagasse	350	Acetone	1	0.01	0.01	1.07	2.09	1.26	2.47
Bagasse	350	Acetone	2	0.01	0.01	1.15	1.27	2.31	2.54
Bagasse	350	Acetone	3	0.00	0.01	0.69	1.64	0.50	1.18
Bagasse	350	Acetone	4	0.01	0.01	0.00	0.00	0.68	1.54
Bagasse	550	Acetone	1	0.00	0.01	0.00	0.00	0.39	1.02
Bagasse	550	Acetone	2	0.00	0.01	0.00	0.00	0.14	0.33
Bagasse	550	Acetone	2	0.00	0.01	0.00	0.00	0.33	0.77
Bagasse	550	Acetone	3	0.00	0.01	0.00	0.00	0.71	1.00
Bagasse	550	Acetone	4	0.00	0.01	0.00	0.00	0.44	1.11
Bagasse	350	H_2O	1	0.00	0.01	0.00	0.00	0.42	0.77
Bagasse	350	H_2O	2	0.00	0.01	0.00	0.00	1.06	1.53
Bagasse	350	H_2O	3	0.00	0.01	0.00	0.00	0.20	0.32
Bagasse	350	H_2O	4	0.00	0.01	0.00	0.00	0.20	0.41
Bagasse	550	H_2O	1	0.00	0.00	0.00	0.00	0.59	0.69
Bagasse	550	H_2O	2	0.00	0.01	0.00	0.00	0.84	1.15
Bagasse	550	H_2O	3	0.00	0.01	0.00	0.00	0.48	1.44
Bagasse	550	H_2O	4	0.00	0.01	0.00	0.00	0.64	1.60
Bagasse	350	HCL	1	0.00	0.01	0.00	0.00	6.82	13.99
Bagasse	350	HCL	2	0.00	0.00	16.05	13.32	13.09	10.86
Bagasse	350	HCL	3	0.00	0.01	3.37	7.98	2.82	6.67
Bagasse	350	HCL	4	0.00	0.01	2.08	4.56	4.83	10.57
Bagasse	550	HCL	1	0.00	0.00	14.71	13.68	3.13	2.91
Bagasse	550	HCL	2	0.00	0.00	0.06	0.05	2.08	2.00
Bagasse	550	HCL	3	0.00	0.01	0.00	0.00	0.71	1.01
Bagasse	550	HCL	4	0.00	0.01	0.00	0.00	1.09	1.81
Bagasse	350	None	1	0.00	0.01	0.00	0.00	0.10	0.25
Bagasse	350	None	2	0.00	0.01	0.00	0.00	1.79	3.42
Bagasse	350	None	3	0.00	0.01	0.68	1.64	0.29	0.69
Bagasse	350	None	4	0.00	0.01	0.00	0.00	0.43	0.74
Bagasse	550	None	1	0.00	0.00	0.00	0.00	0.87	1.09
Bagasse	550	None	2	0.00	0.00	0.00	0.00	0.63	1.39
Bagasse	550	None	3	0.00	0.01	0.00	0.00	0.47	1.01
Bagasse	550	None	4	0.00	0.00	0.00	0.00	0.79	0.80
Bagasse	350	Acetone	1	0.00	0.01	0.00	0.00	0.46	0.84
Bagasse	350	Acetone	2	0.01	0.01	0.00	0.00	0.46	0.70
Bagasse	350	Acetone	3	0.00	0.01	0.00	0.00	1.31	3.29
Bagasse	350	Acetone	4	0.00	0.00	1.43	1.99	1.14	1.59
Bagasse	550	Acetone	1	0.00	0.00	0.00	0.00	4.17	7.09
Bagasse	550	Acetone	2	0.00	0.01	2.17	4.35	1.11	2.22
Bagasse	550	Acetone	3	0.00	0.00	0.00	0.00	2.32	2.00

Bagasse	550	Acetone	4	0.00	0.01	0.00	0.00	1.81	3.41
Bagasse	350	H_2O	1	0.00	0.01	0.38	0.88	0.33	0.75
Bagasse	350	H_2O	2	0.00	0.00	0.00	0.00	4.22	3.88
Bagasse	350	H_2O	3						
Bagasse	350	H_2O	4	0.00	0.00	0.00	0.00	735.95	618.19
Bagasse	550	H_2O	1	0.00	0.00	0.00	0.00	770.58	978.64
Bagasse	550	H_2O	2	0.00	0.01	0.00	0.00	256.49	546.33
Bagasse	550	H_2O	3	0.00	0.00	0.00	0.00	3320.93	996.28
Bagasse	550	H_2O	4	0.00	0.00	0.00	0.00	356.10	441.56
Bagasse	350	HCL	1	0.00	0.01	2.96	6.68	216.85	490.08
Bagasse	350	HCL	1						
Bagasse	350	HCL	2						
Bagasse	350	HCL	3	0.00	0.01	1.63	2.94	269.75	488.25
Bagasse	350	HCL	4	0.00	0.01	0.00	0.00	209.15	347.19
Bagasse	550	HCL	1	0.00	0.00	0.00	0.00	303.36	494.48
Bagasse	550	HCL	2	0.00	0.00	3.34	6.67	394.83	789.67
Bagasse	550	HCL	3	0.00	0.00	10.09	12.62	809.50	1011.87
Bagasse	550	HCL	4	0.00	0.01	0.00	0.00	239.78	434.00
Maize stovers	350	None	1	0.00	0.01	0.00	0.00	179.62	235.30
Maize stovers	350	None	2	0.00	0.01	0.73	1.34	143.13	261.93
Maize stovers	350	None	3	0.01	0.01	0.62	1.19	150.17	289.83
Maize stovers	350	None	4	0.01	0.01	0.00	0.00	170.29	252.03
Maize stovers	550	None	1						
Maize stovers	550	None	2	0.00	0.00	0.00	0.00	492.78	399.15
Maize stovers	550	None	3	0.00	0.01	0.00	0.00	253.05	392.22
Maize stovers	550	None	4	0.00	0.00	0.00	0.00	499.49	489.50
Maize stovers	350	Acetone	1	0.00	0.01	0.00	0.00	145.70	257.89
Maize stovers	350	Acetone	2	0.00	0.01	0.00	0.00	119.83	266.02
Maize stovers	350	Acetone	3	0.00	0.01	0.00	0.00	105.83	234.95
Maize stovers	350	Acetone	4	0.01	0.01	0.33	0.66	123.67	244.87
Maize stovers	550	Acetone	1	0.00	0.01	0.10	0.16	251.09	409.28
Maize stovers	550	Acetone	2	0.00	0.01	0.01	0.03	221.88	441.55
Maize stovers	550	Acetone	3	0.00	0.00	0.00	0.00	779.51	623.61
Maize stovers	550	Acetone	4	0.00	0.01	0.00	0.00	110.69	345.34
Maize stovers	350	H_2O	1	0.00	0.01	0.00	0.00	143.00	298.87
Maize stovers	350	H_2O	2	0.00	0.01	0.00	0.00	210.23	311.14
Maize stovers	350	H_2O	3	0.00	0.01	0.00	0.00	155.12	294.72
Maize stovers	350	H_2O	4						
Maize stovers	550	H_2O	1	0.00	0.01	0.00	0.00	274.28	455.30
Maize stovers	550	H_2O	2	0.00	0.00	0.15	0.13	481.02	432.92

Maize stovers	550	H_2O	3	0.00	0.01	0.06	0.12	167.37	328.04
Maize stovers	550	H_2O	4	0.00	0.01	0.00	0.00	203.09	280.27
Maize stovers	350	HCL	1	0.00	0.01	10.11	13.35	389.64	514.33
Maize stovers	350	HCL	2	0.00	0.01	2.45	4.01	203.86	334.32
Maize stovers	350	HCL	3	0.00	0.01	4.56	8.02	269.64	474.56
Maize stovers	350	HCL	4	0.00	0.01	6.76	13.32	236.51	465.92
Maize stovers	550	HCL	1	0.00	0.01	0.51	1.08	256.30	540.80
Maize stovers	550	HCL	2	0.00	0.01	0.85	1.78	276.18	579.97
Maize stovers	550	HCL	3	0.00	0.01	0.00	0.00	253.72	431.33
Maize stovers	550	HCL	4	0.00	0.00	7.01	8.21	483.50	565.70
Maize stovers	350	None	1	0.00	0.01	0.08	0.14	186.51	331.99
Maize stovers	350	None	2	0.00	0.01	0.00	0.00	117.12	322.07
Maize stovers	350	None	3	0.00	0.01	0.00	0.00	122.58	316.26
Maize stovers	350	None	4	0.00	0.01	0.00	0.00	156.00	315.12
Maize stovers	550	None	1	0.00	0.00	0.00	0.00	437.77	529.71
Maize stovers	550	None	2	0.00	0.01	0.00	0.00	226.30	486.53
Maize stovers	550	None	3	0.00	0.01	0.00	0.00	279.31	488.79
Maize stovers	550	None	4	0.00	0.01	0.00	0.00	225.58	381.22
Maize stovers	350	Acetone	1	0.00	0.01	2.01	4.56	149.61	339.61
Maize stovers	350	Acetone	2	0.00	0.01	5.81	8.07	269.52	374.63
Maize stovers	350	Acetone	3	0.00	0.01	5.73	8.99	208.36	327.12
Maize stovers	350	Acetone	4	0.01	0.01	1.68	3.08	130.45	238.72
Maize stovers	550	Acetone	1	0.00	0.01	4.02	5.58	340.94	473.91
Maize stovers	550	Acetone	2	0.00	0.01	4.69	6.29	310.42	415.96
Maize stovers	550	Acetone	3	0.00	0.01	3.46	5.78	328.29	548.24
Maize stovers	550	Acetone	4	0.00	0.00	11.50	7.24	860.09	541.86
Maize stovers	350	H_2O	1	0.00	0.00	13.76	6.60	865.18	415.29
Maize stovers	350	H_2O	2	0.00	0.01	3.79	7.32	201.56	389.01
Maize stovers	350	H_2O	3	0.00	0.01	2.95	5.19	179.80	316.45
Maize stovers	350	H_2O	4	0.01	0.00	24.24	4.85	1364.79	272.96
Maize stovers	550	H_2O	1	0.00	0.01	2.62	4.88	194.71	362.15
Maize stovers	550	H_2O	2	0.00	0.01	3.68	5.81	284.93	450.19
Maize stovers	550	H_2O	3	0.00	0.00	5.52	6.18	451.17	505.31
Maize stovers	550	H_2O	4	0.00	0.01	3.50	9.16	231.51	606.55
Maize stovers	350	HCL	1	0.00	0.01	12.88	21.77	288.72	487.93
Maize stovers	350	HCL	2						
Maize stovers	350	HCL	3						
Maize stovers	350	HCL	4	0.00	0.01	6.55	10.35	306.94	484.97
Maize stovers	550	HCL	1	0.00	0.00	6.09	10.72	405.90	714.38
Maize stovers	550	HCL	2	0.00	0.00	10.05	12.16	538.53	651.62

Maize stovers	550	HCL	3	0.00	0.00	7.90	11.06	411.75	576.44
Maize stovers	550	HCL	4	0.00	0.00	15.42	18.66	574.97	695.72
Maize cobs	350	None	1	0.00	0.01	4.28	7.03	191.95	314.79
Maize cobs	350	None	2	0.00	0.01	2.92	7.69	140.93	370.65
Maize cobs	350	None	3	0.00	0.01	4.49	7.14	212.53	337.92
Maize cobs	350	None	4	0.00	0.00	14.52	10.89	564.31	423.23
Maize cobs	550	None	1	0.00	0.01	5.10	7.39	273.43	396.47
Maize cobs	550	None	2	0.00	0.01	4.61	7.42	261.12	420.40
Maize cobs	550	None	3	0.00	0.01	6.18	10.44	272.55	460.61
Maize cobs	550	None	4	0.00	0.01	6.36	9.98	253.20	397.52
Maize cobs	350	Acetone	1	0.00	0.01	2.29	4.80	150.37	315.78
Maize cobs	350	Acetone	2	0.00	0.01	3.34	4.48	244.46	327.57
Maize cobs	350	Acetone	3	0.01	0.01	2.37	4.26	153.18	275.73
Maize cobs	350	Acetone	4	0.00	0.01	2.24	5.24	132.89	310.96
Maize cobs	550	Acetone	1	0.00	0.01	2.68	6.76	164.26	413.93
Maize cobs	550	Acetone	2						
Maize cobs	550	Acetone	3	0.00	0.01	4.07	8.34	172.48	353.58
Maize cobs	550	Acetone	4	0.00	0.01	3.72	8.75	149.41	351.11
Maize cobs	350	H_2O	1	0.00	0.01	3.87	7.78	187.54	376.96
Maize cobs	350	H_2O	2	0.00	0.01	8.24	12.85	218.82	341.35
Maize cobs	350	H_2O	3	0.00	0.01	5.36	9.37	225.13	393.97
Maize cobs	350	H_2O	4						
Maize cobs	550	H_2O	1	0.00	0.00	4.71	6.17	320.06	419.27
Maize cobs	550	H_2O	2	0.00	0.01	4.18	6.86	244.16	400.43
Maize cobs	550	H_2O	3	0.00	0.00	11.29	13.89	414.42	509.74
Maize cobs	550	H_2O	4	0.00	0.01	3.32	8.29	172.85	432.13
Maize cobs	350	HCL	1	0.00	0.01	2.90	6.06	178.58	373.24
Maize cobs	350	HCL	2	0.00	0.01	4.61	8.44	224.56	410.95
Maize cobs	350	HCL	3	0.00	0.01	4.55	7.91	231.58	402.95
Maize cobs	350	HCL	4	0.00	0.01	3.37	5.12	281.18	427.39
Maize cobs	550	HCL	1	0.00	0.00	6.26	7.96	412.39	523.74
Maize cobs	550	HCL	2	0.00	0.00	6.32	9.86	345.98	539.73
Maize cobs	550	HCL	3	0.00	0.01	4.86	8.46	324.62	564.84
Maize cobs	550	HCL	4	0.00	0.00	9.63	11.17	481.42	558.45
Maize cobs	350	None	1						
Maize cobs	350	None	2	0.00	0.01	3.78	7.14	224.83	424.93
Maize cobs	350	None	3	0.00	0.01	4.03	7.05	221.10	386.93
Maize cobs	350	None	4	0.00	0.01	3.68	8.09	179.88	395.74
Maize cobs	550	None	1	0.00	0.01	4.44	9.36	291.98	616.07
Maize cobs	550	None	2	0.00	0.01	3.55	8.77	228.57	564.57
Maize cobs	550	None	3	0.00	0.00	7.00	13.58	399.32	774.68

Maize cobs	550	None	4	0.00	0.00	3.86	6.61	324.09	554.20
Maize cobs	350	Acetone	1	0.00	0.01	2.01	5.00	130.60	323.88
Maize cobs	350	Acetone	2	0.00	0.00	30.15	12.36	898.21	368.27
Maize cobs	350	Acetone	3	0.00	0.01	4.82	6.08	303.84	382.84
Maize cobs	350	Acetone	4	0.00	0.01	2.74	4.82	252.29	444.04
Maize cobs	550	Acetone	1	0.00	0.00	6.08	6.69	461.48	507.63
Maize cobs	550	Acetone	2	0.00	0.01	3.02	5.98	212.69	421.13
Maize cobs	550	Acetone	3	0.00	0.01	3.57	7.04	275.11	541.98
Maize cobs	550	Acetone	4	0.00	0.00	1.46	2.75	89.72	168.67
Maize cobs	350	H_2O	1	0.00	0.01	5.86	9.68	223.55	368.86
Maize cobs	350	H_2O	2	0.00	0.01	3.06	5.62	176.79	325.29
Maize cobs	350	H_2O	3	0.00	0.01	2.80	6.62	183.26	432.50
Maize cobs	350	H_2O	4	0.00	0.01	2.84	6.73	185.23	439.00
Maize cobs	550	H_2O	1	0.00	0.00	13.40	10.59	581.15	459.11
Maize cobs	550	H_2O	2	0.00	0.01	3.64	8.00	256.58	564.47
Maize cobs	550	H_2O	3	0.00	0.01	1.87	5.78	155.84	481.55
Maize cobs	550	H_2O	4	0.00	0.00	16.49	26.55	343.21	552.57
Maize cobs	350	HCL	1	0.00	0.01	3.58	6.99	236.38	460.94
Maize cobs	350	HCL	2	0.00	0.01	2.61	6.10	225.54	527.77
Maize cobs	350	HCL	3						
Maize cobs	350	HCL	4	0.00	0.01	2.89	6.41	274.29	608.91
Maize cobs	550	HCL	1	0.00	0.00	8.83	8.48	810.09	777.69
Maize cobs	550	HCL	2	0.00	0.00	5.63	8.84	453.90	712.62
Maize cobs	550	HCL	3	0.00	0.00	5.44	7.51	471.39	650.52
Maize cobs	550	HCL	4	0.00	0.00	5.69	10.13	359.64	640.15
Eucalyptus	350	None	1	0.00	0.01	2.32	3.92	182.22	307.95
Eucalyptus	350	None	2	0.00	0.01	1.99	5.38	132.14	356.79
Eucalyptus	350	None	3	0.00	0.01	1.72	3.79	160.18	352.39
Eucalyptus	350	None	4	0.00	0.01	3.28	5.87	206.23	369.15
Eucalyptus	550	None	1	0.00	0.01	2.57	5.06	177.34	349.37
Eucalyptus	550	None	2	0.00	0.01	3.10	4.92	257.18	408.91
Eucalyptus	550	None	3	0.00	0.01	2.30	4.31	203.97	381.43
Eucalyptus	550	None	4	0.00	0.01	2.23	5.60	163.14	409.48
Eucalyptus	350	Acetone	1	0.00	0.01	2.29	3.99	162.22	282.26
Eucalyptus	350	Acetone	2	0.00	0.01	1.42	3.75	134.93	357.57
Eucalyptus	350	Acetone	3	0.00	0.01	2.14	3.72	170.02	295.84
Eucalyptus	350	Acetone	4	0.00	0.01	1.33	3.50	134.23	354.36
Eucalyptus	550	Acetone	1	0.00	0.00	5.68	5.28	189.75	176.47
Eucalyptus	550	Acetone	2	0.00	0.00	13.09	12.70	521.03	505.40
Eucalyptus	550	Acetone	3	0.00	0.01	3.39	5.79	266.33	455.42
Eucalyptus	550	Acetone	4	0.00	0.00	6.75	5.40	537.50	430.00

Eucalyptus	350	H_2O	1	0.00	0.01	4.10	5.21	245.68	312.01
Eucalyptus	350	H_2O	1	0.00	0.01	3.95	5.01	241.74	307.01
Eucalyptus	350	H_2O	2	0.00	0.01	2.53	4.71	175.64	326.69
Eucalyptus	350	H_2O	3	0.00	0.01	1.60	4.65	108.66	316.19
Eucalyptus	350	H_2O	4	0.00	0.01	2.03	3.67	190.30	344.45
Eucalyptus	550	H_2O	1	0.00	0.00	4.32	5.27	383.50	467.86
Eucalyptus	550	H_2O	2	0.00	0.00	25.05	21.29	1013.70	861.64
Eucalyptus	550	H_2O	3	0.00	0.00	29.11	13.39	1251.18	575.54
Eucalyptus	550	H_2O	4	0.00	0.01	2.29	4.12	212.28	382.11
Eucalyptus	350	HCL	1	0.00	0.01	4.83	9.37	252.19	489.26
Eucalyptus	350	HCL	2	0.00	0.01	3.60	6.05	255.29	428.88
Eucalyptus	350	HCL	3	0.00	0.01	5.10	9.70	210.88	400.68
Eucalyptus	350	HCL	4	0.00	0.01	2.51	4.77	224.05	425.70
Eucalyptus	550	HCL	1	0.00	0.00	5.66	7.47	554.87	732.43
Eucalyptus	550	HCL	2	0.00	0.01	3.52	7.28	278.38	576.24
Eucalyptus	550	HCL	3	0.00	0.00	9.36	11.51	605.54	744.81
Eucalyptus	550	HCL	4	0.00	0.01	3.95	7.11	301.12	542.02
Eucalyptus	350	None	1	0.00	0.01	2.25	4.63	179.71	370.21
Eucalyptus	350	None	2	0.00	0.01	1.60	3.86	157.88	382.06
Eucalyptus	350	None	3	0.00	0.01	2.30	5.33	181.22	420.42
Eucalyptus	350	None	4	0.00	0.00	3.90	5.61	332.68	479.05
Eucalyptus	550	None	1						
Eucalyptus	550	None	2	0.00	0.01	4.69	8.91	268.43	510.01
Eucalyptus	550	None	3	0.00	0.01	3.27	4.61	336.18	474.01
Eucalyptus	550	None	4	0.00	0.01	4.53	5.66	379.01	473.77
Eucalyptus	350	Acetone	1	0.00	0.01	4.02	6.60	218.14	357.75
Eucalyptus	350	Acetone	2	0.00	0.01	3.31	5.53	218.00	364.07
Eucalyptus	350	Acetone	3	0.00	0.01	2.37	5.66	187.93	449.16
Eucalyptus	350	Acetone	4	0.00	0.01	2.44	4.39	199.06	358.31
Eucalyptus	550	Acetone	1	0.00	0.01	1.90	5.41	206.26	585.77
Eucalyptus	550	Acetone	2	0.00	0.00	6.63	7.29	567.90	624.69
Eucalyptus	550	Acetone	3	0.00	0.00	1.69	4.80	77.15	219.11
Eucalyptus	550	Acetone	4	0.00	0.00	3.99	4.39	227.10	249.81
Eucalyptus	350	H_2O	1	0.00	0.01	1.14	2.88	61.93	156.06
Eucalyptus	350	H_2O	2	0.00	0.01	0.65	1.60	78.47	192.24
Eucalyptus	350	H_2O	3	0.00	0.00	0.00	0.00	132.79	288.15
Eucalyptus	350	H_2O	4	0.00	0.01	1.72	3.47	114.55	231.39
Eucalyptus	550	H_2O	1	0.00	0.01	2.23	5.01	160.91	362.05
Eucalyptus	550	H_2O	2	0.00	0.01	2.47	4.35	206.65	363.71

Eucalyptus	550	H_2O	3	0.00	0.01	1.62	2.85	150.73	265.28
Eucalyptus	550	H_2O	4	0.00	0.01	2.71	5.15	188.29	357.74
Eucalyptus	350	HCL	1	0.00	0.01	2.49	3.93	141.11	222.96
Eucalyptus	350	HCL	2	0.00	0.01	0.78	1.94	56.92	141.74
Eucalyptus	350	HCL	3	0.00	0.01	1.96	5.10	109.06	283.54
Eucalyptus	350	HCL	4	0.00	0.01	2.14	4.42	113.80	234.43
Eucalyptus	550	HCL	1	0.00	0.01	1.60	3.85	94.17	226.94
Eucalyptus	550	HCL	2	0.00	0.01	4.15	11.30	222.75	605.88
Eucalyptus	550	HCL	3	0.00	0.01	4.52	9.31	280.60	578.04
Eucalyptus	550	HCL	4	0.00	0.01	2.86	5.52	242.28	467.60
Delonix	350	None	1	0.00	0.00	17.73	13.30	485.41	364.06
Delonix	350	None	2	0.00	0.01	1.67	4.40	109.59	289.32
Delonix	350	None	3	0.00	0.01	2.31	4.29	176.00	327.36
Delonix	350	None	4	0.00	0.01	1.86	3.76	153.81	310.70
Delonix	550	None	1	0.00	0.01	1.84	3.55	194.73	375.83
Delonix	550	None	2	0.00	0.01	3.07	7.39	135.54	326.65
Delonix	550	None	3	0.00	0.01	2.44	5.44	187.20	417.46
Delonix	550	None	4	0.00	0.01	1.76	3.97	175.82	395.60
Delonix	350	Acetone	1	0.00	0.00	13.57	5.43	1065.46	426.19
Delonix	350	Acetone	2	0.00	0.01	3.06	3.98	386.37	502.28
Delonix	350	Acetone	3	0.01	0.01	1.47	3.37	129.68	296.96
Delonix	350	Acetone	4	0.01	0.01	1.62	3.96	127.05	309.99
Delonix	550	Acetone	1	0.00	0.01	2.07	6.33	142.03	433.20
Delonix	550	Acetone	2	0.00	0.01	2.20	6.15	144.22	403.81
Delonix	550	Acetone	3	0.00	0.01	2.84	4.61	296.12	479.72
Delonix	550	Acetone	4	0.00	0.01	1.94	5.07	144.27	377.99
Delonix	350	H_2O	1	0.00	0.01	1.34	3.62	119.14	321.67
Delonix	350	H_2O	2	0.01	0.01	2.34	3.74	208.64	333.82
Delonix	350	H_2O	3	0.01	0.01	1.39	3.06	145.69	320.52
Delonix	350	H_2O	4	0.00	0.01	1.93	5.70	115.32	340.19
Delonix	550	H_2O	1	0.00	0.01	2.04	5.09	157.06	392.65
Delonix	550	H_2O	1	0.00	0.01	2.38	5.95	159.23	398.07
Delonix	550	H_2O	2	0.00	0.01	3.01	4.93	236.48	387.83
Delonix	550	H_2O	3	0.00	0.01	3.52	4.78	360.40	490.15
Delonix	550	H_2O	4						
Delonix	350	HCL	1	0.00	0.01	2.57	4.88	211.08	401.06
Delonix	350	HCL	2	0.00	0.01	5.27	7.86	276.40	411.84
Delonix	350	HCL	3	0.00	0.01	2.36	4.13	202.28	353.99
Delonix	350	HCL	4	0.00	0.01	2.59	4.74	217.72	398.43
Delonix	550	HCL	1	0.00	0.01	3.39	6.00	294.86	521.91

Delonix	550	HCL	2	0.00	0.01	1.81	5.09	154.01	432.76
Delonix	550	HCL	3						
Delonix	550	HCL	4	0.00	0.01	2.50	4.91	257.32	504.34
Delonix	350	None	1	0.00	0.01	1.97	3.86	206.13	404.02
Delonix	350	None	1	0.00	0.01	1.74	3.41	184.66	361.93
Delonix	350	None	2	0.00	0.01	2.28	4.86	234.12	498.69
Delonix	350	None	2	0.00	0.01	2.75	5.85	230.62	491.23
Delonix	350	None	3	0.00	0.01	2.33	6.07	124.03	322.47
Delonix	350	None	3	0.00	0.01	2.20	5.72	138.33	359.65
Delonix	350	None	4	0.00	0.01	0.90	2.96	119.17	392.06
Delonix	350	None	4	0.00	0.01	0.96	3.16	118.09	388.51
Delonix	550	None	1	0.00	0.00	5.45	7.85	383.45	552.16
Delonix	550	None	2	0.00	0.01	1.81	3.51	262.31	508.88
Delonix	550	None	3	0.00	0.01	3.25	6.01	264.13	488.65
Delonix	550	None	4	0.00	0.01	2.65	4.27	327.35	527.03
Delonix	350	Acetone	1	0.00	0.01	1.91	4.33	171.30	388.85
Delonix	350	Acetone	2	0.00	0.01	1.82	3.55	193.28	376.90
Delonix	350	Acetone	3	0.00	0.01	1.65	2.68	220.30	356.89
Delonix	350	Acetone	4	0.00	0.01	1.75	3.10	191.16	338.35
Delonix	550	Acetone	1	0.00	0.01	2.99	5.67	302.45	574.66
Delonix	550	Acetone	2	0.00	0.00	3.52	3.69	485.95	510.25
Delonix	550	Acetone	3						
Delonix	550	Acetone	4	0.00	0.01	2.29	3.95	279.07	480.00
Delonix	350	H_2O	1	0.00	0.01	2.17	3.91	232.69	418.83
Delonix	350	H_2O	2	0.00	0.01	3.24	5.44	221.46	372.05
Delonix	350	H_2O	3						
Delonix	350	H_2O	4	0.00	0.01	2.37	3.94	238.63	396.13
Delonix	550	H_2O	1	0.00	0.01	2.52	4.41	248.47	434.83
Delonix	550	H_2O	2	0.00	0.01	2.37	4.36	296.75	546.01
Delonix	550	H_2O	3	0.00	0.00	1.91	2.97	189.09	293.09
Delonix	550	H_2O	4	0.00	0.01	3.05	5.36	365.85	643.90
Delonix	350	HCL	1	0.00	0.01	3.18	4.54	222.45	318.11
Delonix	350	HCL	2	0.00	0.01	4.02	6.96	260.11	449.98
Delonix	350	HCL	3	0.00	0.01	3.83	6.82	258.15	459.50
Delonix	350	HCL	4	0.00	0.01	3.42	6.39	277.63	519.17
Delonix	550	HCL	1						
Delonix	550	HCL	2	0.00	0.00	3.86	6.02	448.24	699.25
Delonix	550	HCL	3						
Delonix	550	HCL	4						
Tea	350	None	1	0.00	0.01	3.42	6.71	156.26	306.27
Tea	350	None	2	0.00	0.01	1.51	3.64	136.13	328.06

Tea	350	None	3	0.00	0.01	1.16	3.97	86.55	296.86
Tea	350	None	4	0.00	0.01	2.43	3.98	169.51	278.00
Tea	550	None	1	0.00	0.01	2.95	4.78	202.74	328.44
Tea	550	None	2	0.00	0.01	3.11	4.51	255.11	369.90
Tea	550	None	3	0.00	0.01	1.86	3.53	171.83	326.49
Tea	550	None	4	0.00	0.01	1.66	4.56	127.98	351.96
Tea	350	Acetone	1	0.01	0.01	2.05	3.01	156.80	230.50
Tea	350	Acetone	2	0.01	0.01	2.45	4.07	153.86	255.40
Tea	350	Acetone	3	0.00	0.01	1.39	3.42	121.13	297.99
Tea	350	Acetone	4	0.01	0.01	1.21	3.29	101.89	276.13
Tea	550	Acetone	1	0.00	0.01	3.32	4.58	240.49	331.88
Tea	550	Acetone	2	0.00	0.01	2.75	5.59	186.77	379.13
Tea	550	Acetone	3	0.00	0.01	1.95	3.63	203.34	378.21
Tea	550	Acetone	4	0.00	0.01	3.24	7.03	157.14	340.99
Tea	350	H_2O	1	0.00	0.01	2.36	5.47	131.19	304.36
Tea	350	H_2O	2						
Tea	350	H_2O	3	0.00	0.00	4.69	3.89	364.28	302.35
Tea	350	H_2O	4	0.00	0.01	1.82	3.40	151.28	282.90
Tea	550	H_2O	1	0.00	0.01	2.66	4.71	188.29	333.27
Tea	550	H_2O	2	0.00	0.00	5.99	4.91	366.33	300.39
Tea	550	H_2O	3	0.00	0.01	1.58	4.15	127.16	333.15
Tea	550	H_2O	4	0.00	0.01	2.50	3.71	213.39	315.82
Tea	350	HCL	1	0.00	0.01	3.10	5.18	210.28	351.17
Tea	350	HCL	2	0.01	0.01	3.15	4.10	268.93	349.61
Tea	350	HCL	3	0.00	0.01	2.76	4.73	224.10	383.22
Tea	350	HCL	4	0.00	0.01	0.61	0.77	315.74	400.99
Tea	550	HCL	1	0.00	0.01	2.51	4.29	259.64	443.98
Tea	550	HCL	2	0.00	0.01	0.29	0.58	217.34	428.16
Tea	550	HCL	3	0.00	0.01	0.46	0.83	231.33	416.40
Tea	550	HCL	4	0.00	0.01	0.00	0.00	258.80	442.54
Tea	350	None	1	0.00	0.01	0.00	0.00	237.75	351.87
Tea	350	None	2	0.00	0.01	0.00	0.00	176.19	287.19
Tea	350	None	3	0.00	0.01	0.00	0.00	152.64	369.39
Tea	350	None	4						
Tea	550	None	1	0.00	0.01	0.85	1.80	202.65	429.62
Tea	550	None	2	0.00	0.01	0.00	0.00	174.98	409.45
Tea	550	None	3	0.00	0.00	0.00	0.00	489.45	631.39
Tea	550	None	4						
Tea	350	Acetone	1	0.00	0.01	0.29	0.48	229.65	376.62
Tea	350	Acetone	2	0.00	0.01	0.00	0.00	111.26	192.48
Tea	350	Acetone	3	0.00	0.01	0.00	0.00	184.18	300.22

Tea	350	Acetone	4	0.00	0.01	0.83	1.04	260.45	325.56
Tea	550	Acetone	1	0.00	0.00	0.20	0.25	370.95	452.55
Tea	550	Acetone	2	0.00	0.01	0.97	1.41	323.72	469.39
Tea	550	Acetone	3	0.00	0.01	0.00	0.00	333.98	450.87
Tea	550	Acetone	4	0.00	0.01	0.00	0.00	312.20	374.64
Tea	350	H_2O	1	0.00	0.01	0.00	0.00	124.51	336.17
Tea	350	H_2O	2	0.00	0.01	0.00	0.00	127.16	305.18
Tea	350	H_2O	3	0.00	0.01	0.00	0.00	212.42	297.39
Tea	350	H_2O	4	0.00	0.01	0.00	0.00	198.06	338.68
Tea	550	H_2O	1	0.00	0.01	0.00	0.00	248.59	459.89
Tea	550	H_2O	2	0.00	0.01	0.00	0.00	200.43	446.95
Tea	550	H_2O	3	0.00	0.01	0.00	0.00	207.75	415.49
Tea	550	H_2O	4	0.00	0.01	0.00	0.00	260.22	450.19
Tea	350	HCL	1	0.00	0.01	0.00	0.00	151.22	338.73
Tea	350	HCL	2	0.00	0.00	3.45	3.00	566.79	493.10
Tea	350	HCL	3	0.00	0.01	0.00	0.00	107.48	365.45
Tea	350	HCL	4	0.00	0.01	0.11	0.29	120.54	310.99
Tea	550	HCL	1	0.00	0.00	1.92	2.46	453.76	580.81
Tea	550	HCL	2	0.00	0.01	0.00	0.00	355.95	562.40
Tea	550	HCL	3						
Tea	550	HCL	4	0.01	0.01	0.45	0.54	495.83	585.07

Table 3.S7. Data from chapter 1 table 1.4.

Feedstock	Temp (°C)	Treatment	Rep	Al (mg g^{-1})	Al (mg $plant^{-1}$)	K (mg g^{-1})	K (mg $plant^{-1}$)	Ca (mg g^{-1})	Ca (mg $plant^{-1}$)
Rice	350	None	1	27.71	42.39	3791.06	5800.32	2240.22	3427.53
Rice	350	None	2	23.11	45.52	2696.89	5312.87	1807.16	3560.10
Rice	350	None	3	65.80	76.32	4815.49	5585.97	2667.89	3094.75
Rice	350	None	4	25.44	42.73	3430.76	5763.68	1996.91	3354.81
Rice	550	None	1	36.61	75.05	1715.91	3517.62	1068.33	2190.08
Rice	550	None	2	72.86	194.53	1995.35	5327.59	1434.36	3829.74
Rice	550	None	3	27.89	79.48	3305.40	9420.38	2350.55	6699.06
Rice	550	None	4	33.33	38.67	7714.19	8948.46	4660.99	5406.75
Rice	350	Acetone	1	23.84	49.36	2783.81	5762.50	1577.90	3266.26
Rice	350	Acetone	2	155.98	171.58	6928.56	7621.41	4077.62	4485.38
Rice	350	Acetone	3	16.62	44.88	2976.98	8037.85	1598.71	4316.51
Rice	350	Acetone	4	41.41	42.23	4629.98	4722.58	2292.72	2338.58
Rice	550	Acetone	1	56.05	141.26	3715.16	9362.21	1983.11	4997.44
Rice	550	Acetone	2	33.13	69.91	4717.35	9953.61	2319.06	4893.22
Rice	550	Acetone	3						

Rice	550	Acetone	4	34.11	80.17	5130.82	12057.42	2618.33	6153.06
Rice	350	H_2O	1	16.50	37.95	3687.59	8481.46	1853.70	4263.50
Rice	350	H_2O	2	19.62	46.31	2772.63	6543.40	2055.82	4851.74
Rice	350	H_2O	3	36.38	63.30	5632.65	9800.80	3026.58	5266.26
Rice	350	H_2O	4	21.85	56.81	3758.52	9772.15	1859.04	4833.49
Rice	550	H_2O	1	44.32	92.18	5584.18	11615.10	3424.84	7123.66
Rice	550	H_2O	2	21.07	42.56	6005.08	12130.26	2839.50	5735.80
Rice	550	H_2O	3	11.70	21.76	6738.30	12533.24	1590.33	2958.01
Rice	550	H_2O	4	16.81	48.74	4257.45	12346.62	1191.98	3456.74
Rice	350	HCL	1	10.23	17.38	6566.46	11162.99	4534.83	7709.21
Rice	350	HCL	2	9.30	25.93	3665.16	10225.80	1941.61	5417.10
Rice	350	HCL	3	12.15	19.57	6951.67	11192.19	4418.93	7114.49
Rice	350	HCL	4	10.49	28.10	3718.39	9965.30	2855.62	7653.07
Rice	550	HCL	1	20.84	37.93	6566.53	11951.09	4230.57	7699.64
Rice	550	HCL	1	21.72	39.53	5937.26	10805.82	3721.00	6772.22
Rice	550	HCL	2	28.36	56.71	5757.83	11515.67	3115.19	6230.38
Rice	550	HCL	3	85.16	169.47	7980.37	15880.94	4471.29	8897.86
Rice	550	HCL	4	25.32	64.32	5194.93	13195.12	2981.16	7572.14
Rice	350	None	1	18.46	42.27	5007.75	11467.75	2782.99	6373.04
Rice	350	None	2	13.87	33.57	4474.80	10829.01	2849.63	6896.11
Rice	350	None	3	13.66	32.38	3697.49	8763.06	1972.24	4674.21
Rice	350	None	4	14.66	39.88	2127.56	5786.97	1961.34	5334.85
Rice	550	None	1	36.78	87.18	5035.15	11933.30	3421.16	8108.16
Rice	550	None	2	59.23	79.37	12983.42	17397.78	7529.13	10089.03
Rice	550	None	3	42.40	98.38	4849.43	11250.68	3204.86	7435.27
Rice	550	None	4						
Rice	350	Acetone	1	26.42	44.91	4370.34	7429.57	2906.22	4940.58
Rice	350	Acetone	2	14.02	28.61	1920.57	3917.97	2121.42	4327.69
Rice	350	Acetone	3	14.23	25.48	2471.61	4424.19	2593.65	4642.63
Rice	350	Acetone	4	36.26	74.33	6730.31	13797.14	2920.36	5986.74
Rice	550	Acetone	1	37.27	38.76	6999.23	7279.20	4603.57	4787.72
Rice	550	Acetone	2	32.80	58.38	3128.63	5568.96	3020.15	5375.87
Rice	550	Acetone	3	21.26	47.20	6495.31	14419.59	2821.44	6263.61
Rice	550	Acetone	4	31.20	48.67	10196.81	15907.02	4332.95	6759.41
Rice	550	Acetone	4						
Rice	350	H_2O	1	2191.98	4800.43	1942.77	4254.68	-15546.64	-34047.13
Rice	350	H_2O	2	14.29	32.73	2224.55	5094.21	2072.28	4745.52
Rice	350	H_2O	3	25.83	53.46	2992.95	6195.41	2402.18	4972.51
Rice	350	H_2O	4	24.91	62.51	2004.27	5030.71	1326.86	3330.43

Rice	550	H_2O	1	50.09	110.19	3805.64	8372.40	3255.10	7161.21
Rice	550	H_2O	2	236.24	585.88	2818.33	6989.46	3298.38	8179.99
Rice	550	H_2O	3	30.79	60.96	3212.78	6361.30	2336.58	4626.43
Rice	550	H_2O	4	144.60	228.47	4998.07	7896.96	3759.54	5940.08
Rice	350	HCL	1	12.40	30.13	2955.92	7182.89	1588.09	3859.06
Rice	350	HCL	2	163.32	488.32	11.62	34.74	1066.23	3188.02
Rice	350	HCL	3	173.80	427.54	20.15	49.57	1231.82	3030.28
Rice	350	HCL	4	623.30	467.47	49.07	36.80	4049.06	3036.80
Rice	550	HCL	1	411.73	576.42	52.19	73.06	3753.88	5255.43
Rice	550	HCL	2	513.58	575.21	57.61	64.52	4303.69	4820.13
Rice	550	HCL	3	216.72	554.80	46.10	118.01	1766.60	4522.51
Rice	550	HCL	4	238.42	641.34	36.75	98.86	1851.31	4980.02
Bagasse	350	None	1	240.44	379.89	29.87	47.19	2438.02	3852.08
Bagasse	350	None	2	157.49	344.91	47.33	103.66	1074.06	2352.19
Bagasse	350	None	3	151.89	378.20	9.09	22.63	922.90	2298.03
Bagasse	350	None	4	168.45	379.01	18.92	42.58	899.76	2024.46
Bagasse	550	None	1	206.38	375.62	20.90	38.04	1426.81	2596.80
Bagasse	550	None	2	222.40	373.64	26.95	45.28	1380.41	2319.08
Bagasse	550	None	3	164.33	430.53	7.55	19.79	770.16	2017.81
Bagasse	550	None	4	583.17	431.54	98.01	72.52	3556.61	2631.89
Bagasse	350	Acetone	1	144.28	282.79	9.83	19.26	649.44	1272.90
Bagasse	350	Acetone	2	342.91	377.20	55.71	61.29	1551.07	1706.17
Bagasse	350	Acetone	3	117.05	276.25	34.17	80.63	1195.36	2821.06
Bagasse	350	Acetone	4	124.62	280.39	23.71	53.36	1373.63	3090.67
Bagasse	550	Acetone	1	137.44	361.48	15.00	39.45	1692.31	4450.79
Bagasse	550	Acetone	2	172.43	406.92	14.13	33.35	1794.19	4234.29
Bagasse	550	Acetone	2	168.92	398.66	15.53	36.64	1689.13	3986.34
Bagasse	550	Acetone	3	239.39	337.54	27.94	39.39	2846.89	4014.12
Bagasse	550	Acetone	4	143.88	365.46	18.80	47.76	1644.75	4177.66
Bagasse	350	H_2O	1	178.83	323.68	25.81	46.72	1962.73	3552.54
Bagasse	350	H_2O	2	196.93	283.58	30.34	43.69	2394.95	3448.73
Bagasse	350	H_2O	3	175.16	280.25	16.77	26.84	2317.00	3707.21
Bagasse	350	H_2O	4	169.67	339.33	18.50	37.01	1788.63	3577.26
Bagasse	550	H_2O	1	288.48	340.41	59.56	70.28	3112.39	3672.62
Bagasse	550	H_2O	2	221.64	301.43	28.65	38.97	2655.93	3612.06
Bagasse	550	H_2O	3	125.65	376.94	14.66	43.99	1455.93	4367.79
Bagasse	550	H_2O	4	174.64	436.60	24.88	62.19	2101.46	5253.66
Bagasse	350	HCL	1	148.22	303.85	19.39	39.75	1609.61	3299.71
Bagasse	350	HCL	2	553.35	459.28	42.53	35.30	4688.17	3891.18
Bagasse	350	HCL	3	210.04	497.79	13.15	31.17	1454.02	3446.02

Bagasse	350	HCL	4	208.94	457.58	23.07	50.52	1711.04	3747.17
Bagasse	550	HCL	1	567.54	527.81	69.61	64.74	5742.13	5340.18
Bagasse	550	HCL	2	453.04	434.92	49.79	47.80	4397.83	4221.91
Bagasse	550	HCL	3	322.20	457.52	60.25	85.55	2964.47	4209.55
Bagasse	550	HCL	4	275.62	457.54	36.36	60.36	2807.74	4660.85
Bagasse	350	None	1	143.56	344.53	13.23	31.74	1289.00	3093.61
Bagasse	350	None	2	170.66	325.96	20.57	39.28	1578.59	3015.11
Bagasse	350	None	3	152.32	365.56	29.37	70.48	1657.25	3977.40
Bagasse	350	None	4	231.50	395.87	34.48	58.96	2501.53	4277.61
Bagasse	550	None	1	398.12	501.63	45.81	57.72	4294.06	5410.52
Bagasse	550	None	2	272.80	597.43	38.09	83.43	2220.19	4862.22
Bagasse	550	None	3	234.42	499.31	38.44	81.88	2091.28	4454.42
Bagasse	550	None	4	501.27	511.29	57.46	58.61	5093.12	5194.98
Bagasse	350	Acetone	1	205.25	371.51	24.68	44.68	1403.21	2539.82
Bagasse	350	Acetone	2	205.10	311.75	33.01	50.17	1744.70	2651.94
Bagasse	350	Acetone	3	123.81	310.77	34.02	85.39	921.86	2313.87
Bagasse	350	Acetone	4	334.82	465.40	61.35	85.27	2843.55	3952.53
Bagasse	550	Acetone	1	336.74	572.46	33.21	56.46	2614.07	4443.91
Bagasse	550	Acetone	2	256.76	513.52	24.22	48.44	2098.94	4197.87
Bagasse	550	Acetone	3	654.08	562.51	76.26	65.59	6058.57	5210.37
Bagasse	550	Acetone	4	216.02	406.12	42.29	79.50	2456.90	4618.96
Bagasse	350	H_2O	1	142.28	327.24	29.18	67.11	1488.20	3422.87
Bagasse	350	H_2O	2	343.60	316.11	56.00	51.52	4744.37	4364.82
Bagasse	350	H_2O	3						
Bagasse	350	H_2O	4	72.38	60.80	9196.60	7725.15	5154.35	4329.65
Bagasse	550	H_2O	1	75.63	96.05	9659.67	12267.78	5363.61	6811.78
Bagasse	550	H_2O	2	28.46	60.61	2500.50	5326.06	1441.76	3070.94
Bagasse	550	H_2O	3	710.43	213.13	42604.10	12781.23	25956.32	7786.89
Bagasse	550	H_2O	4	38.99	48.35	3786.43	4695.17	2285.01	2833.41
Bagasse	350	HCL	1	27.19	61.44	1656.15	3742.89	1622.36	3666.53
Bagasse	350	HCL	1						
Bagasse	350	HCL	2						
Bagasse	350	HCL	3	27.26	49.34	1987.35	3597.10	1943.15	3517.10
Bagasse	350	HCL	4	46.99	78.00	1882.11	3124.30	1584.74	2630.67
Bagasse	550	HCL	1	26.62	43.40	3395.19	5534.16	2212.76	3606.80
Bagasse	550	HCL	2	58.96	117.91	3010.48	6020.96	2623.80	5247.61
Bagasse	550	HCL	3	122.82	153.52	10421.89	13027.36	6688.64	8360.80
Bagasse	550	HCL	4	38.37	69.46	1980.75	3585.15	1781.34	3224.22
Maize stovers	350	None	1	25.15	32.95	2963.02	3881.56	1381.51	1809.78
Maize stovers	350	None	2	11.35	20.77	2290.41	4191.45	1046.90	1915.82

Maize stovers	350	None	3	20.95	40.44	1839.89	3550.99	975.01	1881.76
Maize stovers	350	None	4	27.41	40.56	2769.86	4099.39	1220.42	1806.22
Maize stovers	550	None	1						
Maize stovers	550	None	2	66.60	53.94	5247.58	4250.54	2822.56	2286.27
Maize stovers	550	None	3	31.75	49.21	3321.63	5148.53	1469.23	2277.31
Maize stovers	550	None	4	50.59	49.58	5692.33	5578.48	3075.53	3014.02
Maize stovers	350	Acetone	1	21.14	37.42	1874.78	3318.35	940.72	1665.08
Maize stovers	350	Acetone	2	11.31	25.10	1744.06	3871.82	734.52	1630.63
Maize stovers	350	Acetone	3	15.54	34.49	1591.51	3533.15	690.26	1532.38
Maize stovers	350	Acetone	4	15.88	31.45	1903.49	3768.92	841.45	1666.06
Maize stovers	550	Acetone	1	33.28	54.25	3058.81	4985.86	1517.53	2473.57
Maize stovers	550	Acetone	2	50.69	100.87	2409.98	4795.85	1252.40	2492.27
Maize stovers	550	Acetone	3	84.04	67.23	7424.49	5939.59	5042.61	4034.09
Maize stovers	550	Acetone	4	64.75	202.03	1448.74	4520.08	719.23	2243.99
Maize stovers	350	H_2O	1	12.27	25.63	1854.99	3876.93	913.01	1908.20
Maize stovers	350	H_2O	2	33.24	49.19	2928.62	4334.35	1423.28	2106.45
Maize stovers	350	H_2O	3	34.35	65.27	2054.65	3903.83	937.75	1781.73
Maize stovers	350	H_2O	4						
Maize stovers	550	H_2O	1	22.41	37.21	2598.88	4314.14	1647.48	2734.82
Maize stovers	550	H_2O	2	80.24	72.21	5054.12	4548.70	3083.52	2775.16
Maize stovers	550	H_2O	3	31.57	61.88	1874.46	3673.93	1084.51	2125.64
Maize stovers	550	H_2O	4	50.05	69.07	2341.40	3231.14	1240.56	1711.98
Maize stovers	350	HCL	1	64.82	85.56	3430.62	4528.42	2961.49	3909.17
Maize stovers	350	HCL	2	62.63	102.72	1764.86	2894.37	1685.60	2764.38
Maize stovers	350	HCL	3	32.12	56.53	2265.39	3987.09	2061.40	3628.06
Maize stovers	350	HCL	4	36.10	71.11	2127.76	4191.68	1739.98	3427.76
Maize stovers	550	HCL	1	24.17	50.99	2146.02	4528.10	2036.04	4296.05
Maize stovers	550	HCL	2	38.16	80.13	2440.38	5124.79	2179.29	4576.51
Maize stovers	550	HCL	3	31.04	52.77	2251.46	3827.49	2124.37	3611.43
Maize stovers	550	HCL	4	34.00	39.78	5059.47	5919.58	4267.14	4992.55
Maize stovers	350	None	1	27.36	48.70	2500.28	4450.51	1213.60	2160.20
Maize stovers	350	None	2	17.75	48.81	1304.10	3586.27	766.24	2107.15
Maize stovers	350	None	3	16.83	43.42	1261.16	3253.80	762.75	1967.90
Maize stovers	350	None	4	27.46	55.48	1893.80	3825.47	1067.60	2156.56

Maize stovers	550	None	1	33.31	40.31	3732.90	4516.81	2580.83	3122.81
Maize stovers	550	None	2	32.74	70.38	2337.92	5026.53	1404.89	3020.51
Maize stovers	550	None	3	33.23	58.16	2222.10	3888.68	1525.19	2669.09
Maize stovers	550	None	4	34.81	58.83	1327.86	2244.08	1639.55	2770.83
Maize stovers	350	Acetone	1	30.28	68.73	1295.52	2940.83	807.90	1833.93
Maize stovers	350	Acetone	2	30.08	41.81	2704.03	3758.61	1724.85	2397.54
Maize stovers	350	Acetone	3	56.56	88.80	1728.32	2713.47	1329.42	2087.20
Maize stovers	350	Acetone	4	30.34	55.52	970.31	1775.66	948.74	1736.19
Maize stovers	550	Acetone	1	62.03	86.23	1850.42	2572.08	1793.24	2492.60
Maize stovers	550	Acetone	2	34.66	46.45	2335.81	3129.98	1827.94	2449.43
Maize stovers	550	Acetone	3	36.96	61.72	2039.30	3405.64	1787.10	2984.47
Maize stovers	550	Acetone	4	83.46	52.58	5781.55	3642.38	4891.10	3081.39
Maize stovers	350	H_2O	1	95.56	45.87	9186.18	4409.37	5115.59	2455.48
Maize stovers	350	H_2O	2	37.25	71.89	2603.24	5024.26	1306.08	2520.73
Maize stovers	350	H_2O	3	42.64	75.05	2245.94	3952.85	1137.58	2002.14
Maize stovers	350	H_2O	4	176.95	35.39	12943.50	2588.70	8517.94	1703.59
Maize stovers	550	H_2O	1	46.21	85.95	1188.09	2209.85	1330.35	2474.45
Maize stovers	550	H_2O	2	42.43	67.04	2630.04	4155.46	1787.59	2824.40
Maize stovers	550	H_2O	3	59.29	66.40	3063.20	3430.79	2309.30	2586.41
Maize stovers	550	H_2O	4	20.36	53.34	2220.73	5818.32	1422.59	3727.20
Maize stovers	350	HCL	1	78.47	132.62	2416.72	4084.26	2136.46	3610.62
Maize stovers	350	HCL	2						
Maize stovers	350	HCL	3						
Maize stovers	350	HCL	4	45.42	71.77	2310.14	3650.02	1992.60	3148.31
Maize stovers	550	HCL	1	58.17	102.38	2725.07	4796.13	2957.21	5204.68
Maize stovers	550	HCL	2	49.47	59.85	5517.50	6676.17	4767.11	5768.20
Maize stovers	550	HCL	3	77.19	108.06	3786.48	5301.07	3225.78	4516.10
Maize stovers	550	HCL	4	53.17	64.34	5668.19	6858.52	4655.83	5633.55
Maize cobs	350	None	1	26.16	42.90	2500.29	4100.48	1388.59	2277.29
Maize cobs	350	None	2	21.51	56.58	1546.72	4067.86	875.28	2301.98
Maize cobs	350	None	3	53.63	85.27	3208.19	5101.02	1566.66	2491.00
Maize cobs	350	None	4	165.95	124.46	9311.17	6983.38	4505.02	3378.76
Maize cobs	550	None	1	57.17	82.90	3232.31	4686.85	1690.18	2450.76
Maize cobs	550	None	2	39.27	63.22	3631.21	5846.25	1810.65	2915.14
Maize cobs	550	None	3	50.42	85.20	3225.73	5451.49	1826.55	3086.87

Maize cobs	550	None	4	49.42	77.59	3143.39	4935.12	1613.30	2532.88
Maize cobs	350	Acetone	1	26.44	55.52	1552.37	3259.98	1008.58	2118.01
Maize cobs	350	Acetone	2	20.25	27.14	2649.11	3549.81	1518.54	2034.84
Maize cobs	350	Acetone	3	15.57	28.02	1803.05	3245.50	892.96	1607.34
Maize cobs	350	Acetone	4	14.95	34.99	1338.81	3132.81	835.84	1955.87
Maize cobs	550	Acetone	1	32.40	81.64	2100.34	5292.86	1011.29	2548.44
Maize cobs	550	Acetone	2						
Maize cobs	550	Acetone	3	17.97	36.85	2286.28	4686.87	1065.81	2184.92
Maize cobs	550	Acetone	4	18.93	44.48	2286.69	5373.72	967.80	2274.32
Maize cobs	350	H_2O	1	18.06	36.30	2060.99	4142.60	1199.96	2411.92
Maize cobs	350	H_2O	2	27.81	43.39	3535.49	5515.36	1559.47	2432.78
Maize cobs	350	H_2O	3	27.90	48.83	2424.25	4242.44	1329.34	2326.34
Maize cobs	350	H_2O	4						
Maize cobs	550	H_2O	1	37.31	48.88	3847.44	5040.15	1985.96	2601.61
Maize cobs	550	H_2O	2	49.80	81.68	3153.75	5172.14	1614.02	2646.99
Maize cobs	550	H_2O	3	56.35	69.31	7335.98	9023.25	3812.06	4688.83
Maize cobs	550	H_2O	4	19.47	48.68	2102.94	5257.36	1096.32	2740.80
Maize cobs	350	HCL	1	12.43	25.98	1815.58	3794.56	1434.19	2997.47
Maize cobs	350	HCL	2	21.24	38.87	2027.87	3711.00	1714.87	3138.22
Maize cobs	350	HCL	3	14.68	25.54	2230.36	3880.83	1783.29	3102.92
Maize cobs	350	HCL	4	20.24	30.77	2556.75	3886.26	1901.47	2890.23
Maize cobs	550	HCL	1	88.03	111.80	4140.67	5258.65	3311.84	4206.04
Maize cobs	550	HCL	2	99.04	154.50	3787.40	5908.35	2715.27	4235.81
Maize cobs	550	HCL	3	24.63	42.86	2733.67	4756.59	2277.20	3962.34
Maize cobs	550	HCL	4	61.91	71.82	5266.82	6109.52	3771.09	4374.47
Maize cobs	350	None	1						
Maize cobs	350	None	2	30.09	56.87	2583.67	4883.13	1448.64	2737.94
Maize cobs	350	None	3	31.71	55.49	2702.60	4729.55	1504.41	2632.71
Maize cobs	350	None	4	17.67	38.86	1787.98	3933.57	1103.89	2428.55
Maize cobs	550	None	1	32.83	69.26	3072.35	6482.67	1797.51	3792.74
Maize cobs	550	None	2	36.75	90.77	2303.93	5690.71	1464.37	3617.00
Maize cobs	550	None	3	40.53	78.63	4033.13	7824.28	2457.73	4768.00
Maize cobs	550	None	4	53.05	90.71	3341.65	5714.21	1956.23	3345.15
Maize cobs	350	Acetone	1	24.30	60.26	1356.96	3365.26	878.52	2178.72
Maize cobs	350	Acetone	2	134.37	55.09	13108.36	5374.43	6470.16	2652.76
Maize cobs	350	Acetone	3	81.76	103.02	3324.74	4189.18	2103.84	2650.84
Maize cobs	350	Acetone	4	22.63	39.84	2270.56	3996.18	1543.55	2716.65
Maize cobs	550	Acetone	1	92.25	101.48	3939.51	4333.46	2867.75	3154.52
Maize cobs	550	Acetone	2	106.89	211.64	1834.44	3632.20	1416.29	2804.26
Maize cobs	550	Acetone	3	37.41	73.70	1974.38	3889.52	1708.48	3365.70
Maize cobs	550	Acetone	4	199.42	374.92	660.51	1241.76	786.16	1477.98

Maize cobs	350	H_2O	1	61.78	101.94	2163.05	3569.03	1361.66	2246.74
Maize cobs	350	H_2O	2	32.79	60.34	1680.59	3092.29	1127.11	2073.88
Maize cobs	350	H_2O	3	19.26	45.46	1918.32	4527.24	1252.46	2955.81
Maize cobs	350	H_2O	4	19.71	46.72	1785.01	4230.47	1134.40	2688.53
Maize cobs	550	H_2O	1	179.00	141.41	5434.08	4292.92	3948.92	3119.65
Maize cobs	550	H_2O	2	43.68	96.10	2695.37	5929.81	1702.41	3745.31
Maize cobs	550	H_2O	3	45.74	141.34	1494.22	4617.13	1015.32	3137.35
Maize cobs	550	H_2O	4	58.20	93.70	3441.16	5540.27	2150.16	3461.76
Maize cobs	350	HCL	1	60.96	118.87	2280.81	4447.58	2011.18	3921.81
Maize cobs	350	HCL	2	33.50	78.38	1642.92	3844.42	1576.34	3688.64
Maize cobs	350	HCL	3						
Maize cobs	350	HCL	4	27.23	60.46	1732.85	3846.93	1911.58	4243.71
Maize cobs	550	HCL	1	67.79	65.08	6610.23	6345.82	5528.28	5307.14
Maize cobs	550	HCL	2	36.96	58.03	3269.45	5133.03	3016.16	4735.37
Maize cobs	550	HCL	3	68.93	95.12	4142.29	5716.36	3441.60	4749.41
Maize cobs	550	HCL	4	60.32	107.36	3002.69	5344.78	2690.04	4788.28
Eucalyptus	350	None	1	29.38	49.65	2145.09	3625.20	1249.23	2111.20
Eucalyptus	350	None	2	20.71	55.92	1409.14	3804.67	888.18	2398.10
Eucalyptus	350	None	3	23.35	51.37	1675.05	3685.10	1148.36	2526.40
Eucalyptus	350	None	4	33.67	60.27	2066.41	3698.88	1308.36	2341.96
Eucalyptus	550	None	1	40.75	80.28	1872.11	3688.07	991.44	1953.14
Eucalyptus	550	None	2	40.41	64.25	2424.27	3854.58	1551.45	2466.81
Eucalyptus	550	None	3	29.95	56.01	2110.66	3946.94	1224.68	2290.16
Eucalyptus	550	None	4	24.73	62.08	1705.26	4280.21	947.19	2377.44
Eucalyptus	350	Acetone	1	13.93	24.23	1906.55	3317.40	1068.04	1858.39
Eucalyptus	350	Acetone	2	28.34	75.09	1248.38	3308.21	857.23	2271.66
Eucalyptus	350	Acetone	3	17.12	29.79	1891.25	3290.78	1177.82	2049.41
Eucalyptus	350	Acetone	4	16.76	44.24	1156.97	3054.41	837.86	2211.95
Eucalyptus	550	Acetone	1	266.90	248.21	2478.14	2304.67	2288.87	2128.65
Eucalyptus	550	Acetone	2	85.19	82.64	6419.30	6226.72	3331.33	3231.39
Eucalyptus	550	Acetone	3	57.45	98.25	3128.31	5349.41	1533.99	2623.12
Eucalyptus	550	Acetone	4	40.16	32.13	7434.28	5947.43	3404.25	2723.40
Eucalyptus	350	H_2O	1	50.90	64.64	2941.02	3735.09	1798.38	2283.94
Eucalyptus	350	H_2O	1	48.55	61.66	2921.66	3710.50	1786.87	2269.32
Eucalyptus	350	H_2O	2	12.99	24.16	2073.69	3857.07	1207.45	2245.86
Eucalyptus	350	H_2O	3	19.15	55.73	1163.02	3384.38	784.20	2282.02
Eucalyptus	350	H_2O	4	19.44	35.18	1941.91	3514.86	1175.48	2127.61
Eucalyptus	550	H_2O	1	65.60	80.03	3551.12	4332.36	2102.02	2564.47
Eucalyptus	550	H_2O	2	176.99	150.44	13709.64	11653.19	9013.55	7661.52
Eucalyptus	550	H_2O	3	202.60	93.20	17963.49	8263.21	9393.69	4321.10

Eucalyptus	550	H_2O	4	45.85	82.53	1939.08	3490.34	1261.04	2269.88
Eucalyptus	350	HCL	1	41.08	79.70	2056.51	3989.62	1939.86	3763.33
Eucalyptus	350	HCL	2	28.97	48.68	1944.53	3266.81	1808.09	3037.59
Eucalyptus	350	HCL	3	28.84	54.80	1781.71	3385.25	1680.64	3193.21
Eucalyptus	350	HCL	4	17.81	33.83	1910.00	3629.01	1595.30	3031.07
Eucalyptus	550	HCL	1	107.83	142.34	4024.30	5312.07	4092.14	5401.63
Eucalyptus	550	HCL	2	32.15	66.55	2005.25	4150.86	2113.28	4374.49
Eucalyptus	550	HCL	3	60.31	74.18	4381.98	5389.84	4629.56	5694.36
Eucalyptus	550	HCL	4	34.93	62.88	2151.75	3873.15	2088.03	3758.45
Eucalyptus	350	None	1	18.47	38.04	1791.21	3689.90	1188.77	2448.86
Eucalyptus	350	None	2	73.82	178.64	1064.40	2575.85	970.26	2348.02
Eucalyptus	350	None	3	59.14	137.20	1489.00	3454.48	1158.15	2686.91
Eucalyptus	350	None	4	52.73	75.93	3341.02	4811.07	2076.21	2989.74
Eucalyptus	550	None	1						
Eucalyptus	550	None	2	43.02	81.74	2234.02	4244.63	1511.94	2872.68
Eucalyptus	550	None	3	74.70	105.32	2138.87	3015.81	1799.21	2536.89
Eucalyptus	550	None	4	35.54	44.42	2780.68	3475.84	2076.19	2595.23
Eucalyptus	350	Acetone	1	46.63	76.48	1893.79	3105.82	1442.97	2366.47
Eucalyptus	350	Acetone	2	31.57	52.73	1876.70	3134.09	1288.08	2151.10
Eucalyptus	350	Acetone	3	23.73	56.71	1629.99	3895.69	1196.13	2858.76
Eucalyptus	350	Acetone	4	30.78	55.40	1450.75	2611.35	1180.03	2124.05
Eucalyptus	550	Acetone	1	17.58	49.94	1695.52	4815.28	1249.13	3547.53
Eucalyptus	550	Acetone	2	94.50	103.95	5073.00	5580.30	3420.91	3763.00
Eucalyptus	550	Acetone	3	101.25	287.56	787.27	2235.84	846.37	2403.68
Eucalyptus	550	Acetone	4	60.68	66.75	1463.70	1610.07	2096.37	2306.01
Eucalyptus	350	H_2O	1	15.73	39.64	415.56	1047.20	587.13	1479.57
Eucalyptus	350	H_2O	2	17.79	43.58	639.41	1566.56	619.98	1518.94
Eucalyptus	350	H_2O	3	361.44	784.32	-521.96	-1132.66	-204.25	-443.21
Eucalyptus	350	H_2O	4	22.19	44.83	1144.76	2312.41	836.08	1688.89
Eucalyptus	550	H_2O	1	11.92	26.82	1550.06	3487.63	823.83	1853.61
Eucalyptus	550	H_2O	2	24.00	42.23	1569.20	2761.79	990.80	1743.80
Eucalyptus	550	H_2O	3	23.26	40.93	1086.84	1912.84	931.58	1639.58
Eucalyptus	550	H_2O	4	25.78	48.98	1477.70	2807.63	1017.93	1934.07
Eucalyptus	350	HCL	1	21.48	33.94	1258.67	1988.71	1271.23	2008.54
Eucalyptus	350	HCL	2	24.21	60.29	397.27	989.21	645.50	1607.29
Eucalyptus	350	HCL	3	18.55	48.24	819.88	2131.69	885.47	2302.23
Eucalyptus	350	HCL	4	19.26	39.68	970.37	1998.97	1026.30	2114.18
Eucalyptus	550	HCL	1	12.66	30.50	612.56	1476.27	1100.65	2652.57
Eucalyptus	550	HCL	2	34.48	93.77	1733.23	4714.37	1726.89	4697.13
Eucalyptus	550	HCL	3	33.79	69.60	1955.70	4028.74	2021.09	4163.45
Eucalyptus	550	HCL	4	65.83	127.06	1543.83	2979.60	1920.97	3707.47

Delonix	350	None	1	70.09	52.57	7203.22	5402.42	3977.24	2982.93
Delonix	350	None	2	24.56	64.85	1187.54	3135.11	710.03	1874.49
Delonix	350	None	3	22.28	41.45	1726.03	3210.41	1065.54	1981.91
Delonix	350	None	4	13.73	27.73	1755.65	3546.42	966.80	1952.94
Delonix	550	None	1	24.23	46.77	1728.85	3336.67	1030.54	1988.94
Delonix	550	None	2	43.77	105.49	1734.81	4180.88	768.59	1852.29
Delonix	550	None	3	19.41	43.27	1845.31	4115.04	917.99	2047.13
Delonix	550	None	4	23.82	53.60	1855.59	4175.08	949.02	2135.30
Delonix	350	Acetone	1	176.22	70.49	10377.51	4151.00	7430.59	2972.23
Delonix	350	Acetone	2	26.62	34.60	3060.22	3978.29	2029.74	2638.66
Delonix	350	Acetone	3	32.76	75.02	1238.32	2835.75	836.72	1916.09
Delonix	350	Acetone	4	37.28	90.96	1285.93	3137.68	722.82	1763.69
Delonix	550	Acetone	1	19.18	58.51	1415.94	4318.63	752.25	2294.36
Delonix	550	Acetone	2	18.00	50.41	1450.17	4060.48	753.98	2111.14
Delonix	550	Acetone	3	33.17	53.73	2512.68	4070.53	1502.50	2434.05
Delonix	550	Acetone	4	24.71	64.73	1581.61	4143.82	788.48	2065.81
Delonix	350	H_2O	1	18.86	50.92	1253.84	3385.36	765.49	2066.82
Delonix	350	H_2O	2	39.12	62.59	2048.08	3276.93	1285.45	2056.73
Delonix	350	H_2O	3	15.61	34.33	1651.97	3634.34	922.42	2029.32
Delonix	350	H_2O	4	32.36	95.47	1176.44	3470.51	730.03	2153.58
Delonix	550	H_2O	1	47.07	117.68	1628.69	4071.72	894.68	2236.69
Delonix	550	H_2O	1	44.22	110.54	1659.57	4148.94	906.50	2266.24
Delonix	550	H_2O	2	53.82	88.27	2493.51	4089.35	1313.59	2154.28
Delonix	550	H_2O	3	240.08	326.51	3029.31	4119.86	1760.28	2393.99
Delonix	550	H_2O	4						
Delonix	350	HCL	1	25.60	48.64	1641.09	3118.06	1575.01	2992.51
Delonix	350	HCL	2	29.90	44.56	2207.37	3288.98	2036.47	3034.34
Delonix	350	HCL	3	30.09	52.65	1833.05	3207.84	1469.80	2572.14
Delonix	350	HCL	4	15.49	28.34	1816.64	3324.45	1679.87	3074.16
Delonix	550	HCL	1	34.04	60.24	2405.22	4257.24	2189.33	3875.11
Delonix	550	HCL	2	35.97	101.08	1329.04	3734.61	1206.36	3389.86
Delonix	550	HCL	3						
Delonix	550	HCL	4	31.25	61.25	2122.26	4159.62	1859.77	3645.14
Delonix	350	None	1	22.78	44.64	1755.72	3441.22	1148.37	2250.81
Delonix	350	None	1	22.75	44.58	1598.04	3132.16	1058.35	2074.37
Delonix	350	None	2	30.11	64.13	1861.96	3965.97	1412.04	3007.64
Delonix	350	None	2	32.58	69.40	1793.40	3819.94	1397.85	2977.43
Delonix	350	None	3	24.57	63.89	1046.43	2720.71	755.91	1965.38
Delonix	350	None	3	19.73	51.29	1218.84	3168.98	851.14	2212.97
Delonix	350	None	4	28.67	94.33	856.25	2817.06	679.71	2236.26
Delonix	350	None	4	28.64	94.22	845.24	2780.85	682.01	2243.82

Delonix	550	None	1	46.26	66.61	3039.54	4376.93	2134.86	3074.20
Delonix	550	None	2	65.63	127.32	1694.34	3287.02	1354.33	2627.39
Delonix	550	None	3	31.38	58.06	1861.00	3442.85	2041.13	3776.09
Delonix	550	None	4	42.99	69.22	1770.05	2849.78	1666.52	2683.09
Delonix	350	Acetone	1	22.44	50.94	1277.12	2899.06	1041.46	2364.11
Delonix	350	Acetone	2	13.83	26.98	1523.70	2971.22	1124.09	2191.98
Delonix	350	Acetone	3	17.80	28.84	1506.29	2440.19	1323.31	2143.77
Delonix	350	Acetone	4	15.93	28.20	1408.69	2493.39	1197.80	2120.11
Delonix	550	Acetone	1	56.33	107.03	1675.93	3184.26	1588.69	3018.51
Delonix	550	Acetone	2	55.11	57.87	2935.17	3081.93	2758.15	2896.06
Delonix	550	Acetone	3						
Delonix	550	Acetone	4	18.31	31.49	1411.92	2428.50	1466.13	2521.74
Delonix	350	H_2O	1	23.69	42.64	1771.39	3188.51	1350.49	2430.88
Delonix	350	H_2O	2	27.98	47.01	2842.05	4774.65	1535.28	2579.26
Delonix	350	H_2O	3						
Delonix	350	H_2O	4	26.42	43.86	2040.68	3387.52	1276.19	2118.48
Delonix	550	H_2O	1	34.76	60.82	2047.96	3583.93	1460.71	2556.24
Delonix	550	H_2O	2	145.37	267.48	1930.97	3552.98	1540.82	2835.11
Delonix	550	H_2O	3	118.36	183.46	1172.28	1817.03	1667.60	2584.78
Delonix	550	H_2O	4	30.73	54.08	2119.35	3730.05	1872.13	3294.96
Delonix	350	HCL	1	21.96	31.41	2566.37	3669.90	1736.38	2483.02
Delonix	350	HCL	2	16.41	28.38	2078.55	3595.90	1880.53	3253.32
Delonix	350	HCL	3	72.66	129.34	1913.21	3405.52	1795.69	3196.33
Delonix	350	HCL	4	29.68	55.51	2165.68	4049.82	1900.44	3553.83
Delonix	550	HCL	1						
Delonix	550	HCL	2	83.47	130.22	2726.74	4253.72	2986.38	4658.75
Delonix	550	HCL	3						
Delonix	550	HCL	4						
Tea	350	None	1	25.07	49.14	1742.13	3414.58	1091.34	2139.03
Tea	350	None	2	21.81	52.57	1308.64	3153.82	866.50	2088.26
Tea	350	None	3	12.87	44.16	1032.72	3542.22	623.21	2137.62
Tea	350	None	4	40.31	66.11	2502.87	4104.71	1312.00	2151.68
Tea	550	None	1	39.91	64.65	2884.23	4672.45	1297.05	2101.22
Tea	550	None	2	47.09	68.28	2615.77	3792.87	1423.41	2063.94
Tea	550	None	3	27.06	51.41	2121.65	4031.14	1072.27	2037.31
Tea	550	None	4	13.34	36.69	1479.20	4067.81	798.13	2194.86
Tea	350	Acetone	1	32.74	48.13	1814.52	2667.34	1018.20	1496.76
Tea	350	Acetone	2	23.31	38.69	1958.75	3251.52	974.36	1617.44
Tea	350	Acetone	3	16.71	41.11	1201.89	2956.65	792.60	1949.80
Tea	350	Acetone	4	10.73	29.09	1220.45	3307.43	663.80	1798.91
Tea	550	Acetone	1	70.50	97.28	2557.39	3529.20	1351.65	1865.28

Tea	550	Acetone	2	39.30	79.78	2225.05	4516.85	1051.19	2133.92
Tea	550	Acetone	3	13.74	25.55	2138.10	3976.86	1108.02	2060.92
Tea	550	Acetone	4	39.90	86.57	1979.17	4294.80	912.79	1980.76
Tea	350	H_2O	1	15.89	36.87	1576.94	3658.49	985.35	2286.01
Tea	350	H_2O	2						
Tea	350	H_2O	3	61.04	50.66	3984.24	3306.92	2690.72	2233.30
Tea	350	H_2O	4	31.04	58.04	1880.73	3516.96	1103.15	2062.88
Tea	550	H_2O	1	80.86	143.13	2343.73	4148.41	1203.11	2129.51
Tea	550	H_2O	2	66.63	54.64	4387.06	3597.39	2409.01	1975.39
Tea	550	H_2O	3	22.15	58.04	1359.52	3561.93	744.72	1951.16
Tea	550	H_2O	4	45.72	67.66	2667.85	3948.42	1391.15	2058.91
Tea	350	HCL	1	28.36	47.36	1782.81	2977.29	1429.69	2387.58
Tea	350	HCL	2	31.74	41.27	2483.10	3228.04	2014.13	2618.36
Tea	350	HCL	3	24.90	42.59	2022.53	3458.52	1764.97	3018.10
Tea	350	HCL	4	33.65	42.74	2796.66	3551.76	2154.49	2736.20
Tea	550	HCL	1	220.44	376.95	2310.18	3950.40	1860.30	3181.11
Tea	550	HCL	2	24.72	48.70	2003.71	3947.31	1579.64	3111.89
Tea	550	HCL	3	46.24	83.24	2078.38	3741.09	1595.24	2871.43
Tea	550	HCL	4	35.57	60.82	2074.96	3548.18	1797.61	3073.91
Tea	350	None	1	33.83	50.07	2349.67	3477.52	1502.27	2223.35
Tea	350	None	2	20.80	33.91	1660.00	2705.80	1124.18	1832.41
Tea	350	None	3	16.95	41.01	1580.60	3825.05	967.10	2340.38
Tea	350	None	4						
Tea	550	None	1	47.79	101.31	2070.77	4390.04	1192.24	2527.55
Tea	550	None	2	22.90	53.59	1242.20	2906.74	1044.74	2444.70
Tea	550	None	3	71.90	92.75	4511.92	5820.37	3030.12	3908.85
Tea	550	None	4						
Tea	350	Acetone	1	22.56	36.99	1957.94	3211.02	1381.41	2265.51
Tea	350	Acetone	2	31.62	54.70	827.30	1431.24	1036.58	1793.29
Tea	350	Acetone	3	25.98	42.35	1374.76	2240.86	1124.43	1832.82
Tea	350	Acetone	4	29.52	36.90	2761.31	3451.64	1622.21	2027.76
Tea	550	Acetone	1	30.01	36.62	2858.98	3487.95	2266.63	2765.29
Tea	550	Acetone	2	52.32	75.86	2208.96	3202.99	1766.99	2562.13
Tea	550	Acetone	3	36.66	49.49	2613.82	3528.66	1844.03	2489.45
Tea	550	Acetone	4	59.85	71.82	2060.64	2472.76	1860.51	2232.61
Tea	350	H_2O	1	12.15	32.82	1333.20	3599.63	702.01	1895.43
Tea	350	H_2O	2	16.52	39.64	1098.16	2635.59	789.70	1895.28
Tea	350	H_2O	3	36.11	50.55	2299.53	3219.35	1426.37	1996.92
Tea	350	H_2O	4	16.19	27.68	1867.77	3193.89	1319.19	2255.81
Tea	550	H_2O	1	23.69	43.82	1975.34	3654.39	1482.37	2742.38

Tea	550	H_2O	2	25.93	57.83	1388.44	3096.21	1008.96	2249.98
Tea	550	H_2O	3	21.12	42.23	1910.64	3821.29	1245.06	2490.13
Tea	550	H_2O	4	23.00	39.79	2254.19	3899.75	1349.87	2335.28
Tea	350	HCL	1	10.08	22.57	1086.36	2433.46	1005.59	2252.51
Tea	350	HCL	2	83.26	72.44	6751.78	5874.04	4173.50	3630.95
Tea	350	HCL	3	11.88	40.39	821.32	2792.49	751.54	2555.22
Tea	350	HCL	4	20.18	52.07	1100.05	2838.13	974.40	2513.96
Tea	550	HCL	1	55.20	70.65	3435.63	4397.61	3386.73	4335.02
Tea	550	HCL	2	52.95	83.67	2618.69	4137.53	2539.48	4012.38
Tea	550	HCL	3						
Tea	550	HCL	4	47.24	55.75	2960.02	3492.83	2956.84	3489.07

Table 3.S8. Data from chapter 1 table 1.4.

Feedstock	Temp (°C)	Treatment	Rep	Mn (mg g^{-1})	Mn (mg $plant^{-1}$)	Fe (mg g^{-1})	Fe (mg $plant^{-1}$)	Ni (mg g^{-1})	Ni (mg $plant^{-1}$)
Rice	350	None	1	24.79	37.93	33.48	51.22	0.06	0.09
Rice	350	None	2	19.86	39.11	29.92	58.94	0.06	0.11
Rice	350	None	3	34.53	40.05	67.07	77.80	0.11	0.13
Rice	350	None	4	22.18	37.26	37.73	63.39	0.07	0.12
Rice	550	None	1	12.30	25.21	22.11	45.33	0.07	0.14
Rice	550	None	2	14.93	39.85	41.69	111.31	0.06	0.16
Rice	550	None	3	24.15	68.82	36.76	104.77	0.07	0.19
Rice	550	None	4	40.54	47.03	45.63	52.93	0.29	0.34
Rice	350	Acetone	1	14.54	30.10	28.17	58.32	0.06	0.12
Rice	350	Acetone	2	79.37	87.31	149.06	163.96	0.17	0.19
Rice	350	Acetone	3	2.20	5.95	9.00	24.29	0.04	0.12
Rice	350	Acetone	4	17.40	17.75	31.82	32.46	0.09	0.09
Rice	550	Acetone	1	5.02	12.65	26.02	65.56	0.09	0.22
Rice	550	Acetone	2	3.56	7.52	17.90	37.77	0.07	0.15
Rice	550	Acetone	3						
Rice	550	Acetone	4	5.50	12.92	18.27	42.92	0.11	0.26
Rice	350	H_2O	1	16.88	38.82	19.29	44.37	0.04	0.10
Rice	350	H_2O	2	9.34	22.04	7.47	17.62	0.08	0.18
Rice	350	H_2O	3	28.64	49.83	45.90	79.86	0.09	0.16
Rice	350	H_2O	4	18.60	48.37	21.93	57.02	0.09	0.22
Rice	550	H_2O	1	9.26	19.25	28.61	59.52	0.13	0.26
Rice	550	H_2O	2	3.62	7.32	12.66	25.58	0.04	0.08
Rice	550	H_2O	3	4.74	8.82	9.58	17.82	0.14	0.27
Rice	550	H_2O	4	3.82	11.09	12.60	36.53	0.06	0.16

Rice	350	HCL	1	21.94	37.31	6.18	10.51	0.12	0.21
Rice	350	HCL	2	5.99	16.70	6.86	19.13	0.04	0.11
Rice	350	HCL	3	21.83	35.14	8.51	13.71	0.11	0.17
Rice	350	HCL	4	9.62	25.79	2.77	7.42	0.08	0.22
Rice	550	HCL	1	11.05	20.11	13.99	25.46	0.10	0.18
Rice	550	HCL	1	9.24	16.82	12.28	22.35	0.12	0.22
Rice	550	HCL	2	10.58	21.15	20.32	40.64	0.09	0.17
Rice	550	HCL	3	30.71	61.12	62.27	123.93	0.14	0.29
Rice	550	HCL	4	7.86	19.96	14.49	36.81	0.06	0.16
Rice	350	None	1	16.39	37.53	14.03	32.13	0.07	0.17
Rice	350	None	2	3.97	9.61	7.21	17.46	0.09	0.22
Rice	350	None	3	5.97	14.14	11.37	26.95	0.15	0.35
Rice	350	None	4	6.45	17.55	9.01	24.50	0.07	0.20
Rice	550	None	1	33.99	80.56	46.45	110.08	0.09	0.21
Rice	550	None	2	118.17	158.35	87.60	117.39	0.22	0.30
Rice	550	None	3	43.66	101.30	57.21	132.74	0.10	0.24
Rice	550	None	4						
Rice	350	Acetone	1	28.78	48.92	37.69	64.07	0.10	0.16
Rice	350	Acetone	2	15.47	31.56	22.78	46.47	0.06	0.11
Rice	350	Acetone	3	43.26	77.43	21.63	38.71	0.09	0.15
Rice	350	Acetone	4	33.46	68.60	48.07	98.54	0.11	0.23
Rice	550	Acetone	1	41.87	43.54	63.11	65.64	0.21	0.22
Rice	550	Acetone	2	25.17	44.80	45.52	81.02	0.12	0.21
Rice	550	Acetone	3	0.23	0.51	29.66	65.84	0.09	0.19
Rice	550	Acetone	4	46.53	72.58	42.22	65.86	0.15	0.23
Rice	550	Acetone	4						
Rice	350	H_2O	1	-19332.51	-42338.19	-291.15	-637.62	-10.40	-22.78
Rice	350	H_2O	2	18.66	42.74	20.64	47.27	0.07	0.15
Rice	350	H_2O	3	32.61	67.51	35.18	72.82	0.08	0.17
Rice	350	H_2O	4	31.91	80.10	35.06	88.01	0.06	0.16
Rice	550	H_2O	1	26.34	57.95	82.77	182.10	0.14	0.30
Rice	550	H_2O	2	44.57	110.53	184.54	457.66	0.08	0.19
Rice	550	H_2O	3	37.78	74.80	41.21	81.60	0.10	0.20
Rice	550	H_2O	4	66.60	105.23	147.52	233.08	0.18	0.28
Rice	350	HCL	1	40.91	99.41	17.92	43.55	0.05	0.13
Rice	350	HCL	2	17.44	52.16	17.33	51.80	11.89	35.56
Rice	350	HCL	3	21.01	51.69	20.89	51.38	18.34	45.12
Rice	350	HCL	4	112.91	84.68	112.52	84.39	56.29	42.22
Rice	550	HCL	1	32.52	45.52	32.04	44.86	49.02	68.63
Rice	550	HCL	2	40.79	45.69	40.38	45.23	54.51	61.05

Rice	550	HCL	3	15.19	38.89	14.99	38.39	39.78	101.84
Rice	550	HCL	4	17.52	47.14	17.34	46.64	33.15	89.16
Bagasse	350	None	1	22.50	35.55	22.27	35.18	28.00	44.25
Bagasse	350	None	2	14.70	32.20	14.58	31.93	58.19	127.43
Bagasse	350	None	3	10.90	27.14	10.81	26.91	13.54	33.72
Bagasse	350	None	4	10.79	24.29	10.69	24.05	26.30	59.19
Bagasse	550	None	1	12.52	22.79	12.38	22.52	29.09	52.94
Bagasse	550	None	2	14.40	24.20	14.25	23.93	37.92	63.70
Bagasse	550	None	3	9.63	25.23	9.52	24.94	13.08	34.28
Bagasse	550	None	4	40.27	29.80	39.85	29.49	142.14	105.18
Bagasse	350	Acetone	1	8.89	17.42	8.78	17.20	22.79	44.66
Bagasse	350	Acetone	2	23.00	25.31	22.80	25.08	81.90	90.09
Bagasse	350	Acetone	3	11.91	28.10	11.78	27.80	36.87	87.00
Bagasse	350	Acetone	4	8.28	18.62	8.16	18.35	32.17	72.38
Bagasse	550	Acetone	1	8.77	23.08	8.64	22.73	14.32	37.66
Bagasse	550	Acetone	2	11.58	27.33	11.39	26.89	17.12	40.41
Bagasse	550	Acetone	2	11.85	27.97	11.68	27.57	15.44	36.44
Bagasse	550	Acetone	3	17.12	24.13	16.89	23.81	25.80	36.37
Bagasse	550	Acetone	4	11.33	28.79	11.18	28.40	17.70	44.97
Bagasse	350	H_2O	1	15.04	27.23	14.86	26.89	24.88	45.03
Bagasse	350	H_2O	2	14.21	20.46	13.99	20.14	27.58	39.72
Bagasse	350	H_2O	3	10.95	17.52	10.75	17.21	16.41	26.26
Bagasse	350	H_2O	4	11.33	22.67	11.15	22.30	18.72	37.44
Bagasse	550	H_2O	1	19.67	23.21	19.33	22.81	55.00	64.90
Bagasse	550	H_2O	2	15.63	21.25	15.39	20.93	28.58	38.87
Bagasse	550	H_2O	3	8.63	25.90	8.49	25.48	14.66	43.99
Bagasse	550	H_2O	4	12.04	30.10	11.86	29.66	22.94	57.34
Bagasse	350	HCL	1	16.12	33.05	15.96	32.73	18.14	37.18
Bagasse	350	HCL	2	75.81	62.92	75.38	62.56	40.66	33.75
Bagasse	350	HCL	3	30.02	71.15	29.88	70.83	13.03	30.89
Bagasse	350	HCL	4	31.18	68.28	31.04	67.97	21.52	47.12
Bagasse	550	HCL	1	48.78	45.37	48.26	44.88	66.72	62.05
Bagasse	550	HCL	2	33.17	31.85	32.75	31.44	52.93	50.81
Bagasse	550	HCL	3	26.62	37.80	26.34	37.40	52.88	75.10
Bagasse	550	HCL	4	23.47	38.95	23.22	38.55	33.54	55.68
Bagasse	350	None	1	10.71	25.70	10.54	25.30	13.78	33.07
Bagasse	350	None	2	15.36	29.33	15.18	28.98	19.56	37.35
Bagasse	350	None	3	9.52	22.84	9.35	22.43	25.56	61.34
Bagasse	350	None	4	19.43	33.23	19.20	32.84	32.93	56.31
Bagasse	550	None	1	33.96	42.79	33.54	42.26	53.76	67.73
Bagasse	550	None	2	19.59	42.90	19.28	42.22	40.96	89.69

Bagasse	550	None	3	20.61	43.89	20.36	43.36	33.99	72.40
Bagasse	550	None	4	36.42	37.15	35.92	36.64	53.88	54.96
Bagasse	350	Acetone	1	15.65	28.32	15.48	28.02	23.03	41.69
Bagasse	350	Acetone	2	16.72	25.41	16.54	25.14	28.75	43.70
Bagasse	350	Acetone	3	10.09	25.32	9.96	24.99	30.48	76.51
Bagasse	350	Acetone	4	29.66	41.23	29.33	40.77	57.65	80.13
Bagasse	550	Acetone	1	24.12	41.00	23.83	40.51	31.69	53.88
Bagasse	550	Acetone	2	15.11	30.22	14.85	29.71	22.85	45.69
Bagasse	550	Acetone	3	60.04	51.64	59.37	51.06	75.80	65.19
Bagasse	550	Acetone	4	13.65	25.67	13.43	25.26	39.71	74.66
Bagasse	350	H_2O	1	11.59	26.66	11.44	26.31	27.22	62.61
Bagasse	350	H_2O	2	20.39	18.76	19.96	18.37	50.44	46.41
Bagasse	350	H_2O	3						
Bagasse	350	H_2O	4	48.05	40.36	72.71	61.08	0.00	0.00
Bagasse	550	H_2O	1	50.23	63.79	75.69	96.12	0.00	0.00
Bagasse	550	H_2O	2	20.66	44.01	29.24	62.29	0.00	0.00
Bagasse	550	H_2O	3	244.93	73.48	610.17	183.05	0.00	0.00
Bagasse	550	H_2O	4	22.95	28.46	36.18	44.86	0.00	0.00
Bagasse	350	HCL	1	31.64	71.51	26.40	59.65	0.06	0.14
Bagasse	350	HCL	1						
Bagasse	350	HCL	2						
Bagasse	350	HCL	3	40.10	72.59	24.22	43.83	0.07	0.13
Bagasse	350	HCL	4	16.96	28.15	41.90	69.55	0.00	0.00
Bagasse	550	HCL	1	20.33	33.14	27.69	45.13	0.00	0.00
Bagasse	550	HCL	2	60.52	121.04	52.38	104.76	0.14	0.28
Bagasse	550	HCL	3	90.54	113.18	130.56	163.20	0.41	0.52
Bagasse	550	HCL	4	16.23	29.38	34.49	62.42	0.00	0.00
Maize stovers	350	None	1	11.80	15.46	23.63	30.96	0.00	0.00
Maize stovers	350	None	2	10.88	19.91	12.55	22.97	0.00	0.00
Maize stovers	350	None	3	14.53	28.04	20.91	40.36	0.00	0.00
Maize stovers	350	None	4	11.03	16.33	25.25	37.37	0.00	0.00
Maize stovers	550	None	1						
Maize stovers	550	None	2	42.66	34.56	63.32	51.29	0.00	0.00
Maize stovers	550	None	3	22.19	34.40	30.56	47.37	0.00	0.00
Maize stovers	550	None	4	35.79	35.07	49.93	48.93	0.00	0.00
Maize stovers	350	Acetone	1	9.45	16.72	19.99	35.39	0.00	0.00
Maize stovers	350	Acetone	2	9.01	20.00	11.51	25.55	0.00	0.00
Maize stovers	350	Acetone	3	8.21	18.24	14.65	32.53	0.00	0.00

Maize stovers	350	Acetone	4	9.38	18.57	15.64	30.97	0.00	0.00
Maize stovers	550	Acetone	1	17.34	28.27	30.36	49.49	0.00	0.00
Maize stovers	550	Acetone	2	15.20	30.25	43.88	87.32	0.00	0.00
Maize stovers	550	Acetone	3	62.50	50.00	84.82	67.86	0.00	0.00
Maize stovers	550	Acetone	4	10.30	32.13	56.39	175.94	0.00	0.00
Maize stovers	350	H_2O	1	12.36	25.82	13.55	28.31	0.00	0.00
Maize stovers	350	H_2O	2	15.26	22.58	34.58	51.18	0.00	0.00
Maize stovers	350	H_2O	3	10.37	19.70	31.24	59.36	0.00	0.00
Maize stovers	350	H_2O	4						
Maize stovers	550	H_2O	1	23.03	38.23	23.46	38.94	0.00	0.00
Maize stovers	550	H_2O	2	36.32	32.69	72.27	65.04	0.00	0.00
Maize stovers	550	H_2O	3	13.91	27.25	28.11	55.09	0.00	0.00
Maize stovers	550	H_2O	4	19.20	26.49	44.67	61.64	0.00	0.00
Maize stovers	350	HCL	1	60.63	80.04	56.34	74.37	0.18	0.24
Maize stovers	350	HCL	2	42.01	68.89	56.78	93.11	0.00	0.00
Maize stovers	350	HCL	3	48.99	86.22	21.88	38.50	0.08	0.14
Maize stovers	350	HCL	4	37.35	73.58	32.11	63.26	0.00	0.00
Maize stovers	550	HCL	1	27.32	57.65	23.61	49.81	0.17	0.36
Maize stovers	550	HCL	2	30.37	63.77	34.51	72.48	0.00	0.00
Maize stovers	550	HCL	3	41.26	70.14	30.94	52.60	0.06	0.10
Maize stovers	550	HCL	4	49.61	58.05	35.70	41.77	0.12	0.14
Maize stovers	350	None	1	12.79	22.77	25.64	45.63	0.00	0.00
Maize stovers	350	None	2	9.37	25.76	17.04	46.86	0.07	0.20
Maize stovers	350	None	3	8.69	22.42	15.78	40.70	0.00	0.00
Maize stovers	350	None	4	10.24	20.68	25.65	51.80	0.08	0.17
Maize stovers	550	None	1	23.19	28.06	33.38	40.39	0.00	0.00
Maize stovers	550	None	2	16.35	35.14	30.05	64.61	0.08	0.17
Maize stovers	550	None	3	18.28	32.00	30.94	54.14	0.14	0.25
Maize stovers	550	None	4	17.99	30.41	32.41	54.77	0.04	0.07
Maize stovers	350	Acetone	1	10.77	24.44	25.62	58.16	0.03	0.07
Maize stovers	350	Acetone	2	24.42	33.94	30.08	41.80	0.07	0.09
Maize stovers	350	Acetone	3	16.21	25.44	46.96	73.73	0.05	0.08
Maize stovers	350	Acetone	4	9.37	17.14	26.27	48.07	0.00	0.00
Maize stovers	550	Acetone	1	19.02	26.43	54.12	75.22	0.23	0.31

Maize stovers	550	Acetone	2	15.69	21.02	29.76	39.87	0.00	0.00
Maize stovers	550	Acetone	3	17.99	30.04	30.72	51.30	0.00	0.00
Maize stovers	550	Acetone	4	58.84	37.07	78.17	49.25	0.00	0.00
Maize stovers	350	H_2O	1	58.86	28.25	88.70	42.58	0.64	0.31
Maize stovers	350	H_2O	2	16.03	30.95	32.31	62.35	0.00	0.00
Maize stovers	350	H_2O	3	13.30	23.40	35.25	62.03	0.00	0.00
Maize stovers	350	H_2O	4	107.56	21.51	182.83	36.57	0.00	0.00
Maize stovers	550	H_2O	1	14.18	26.38	38.37	71.36	0.12	0.21
Maize stovers	550	H_2O	2	20.50	32.39	34.64	54.74	0.00	0.00
Maize stovers	550	H_2O	3	41.11	46.05	54.24	60.75	0.00	0.00
Maize stovers	550	H_2O	4	17.78	46.58	19.95	52.27	0.00	0.00
Maize stovers	350	HCL	1	34.17	57.75	62.89	106.28	0.00	0.00
Maize stovers	350	HCL	2						
Maize stovers	350	HCL	3						
Maize stovers	350	HCL	4	42.72	67.50	38.26	60.45	0.00	0.00
Maize stovers	550	HCL	1	44.65	78.59	52.32	92.08	0.24	0.42
Maize stovers	550	HCL	2	54.40	65.83	46.93	56.78	0.00	0.00
Maize stovers	550	HCL	3	44.13	61.78	63.65	89.11	0.00	0.00
Maize stovers	550	HCL	4	68.53	82.92	45.84	55.47	0.00	0.00
Maize cobs	350	None	1	18.09	29.66	24.46	40.12	0.00	0.00
Maize cobs	350	None	2	15.13	39.78	20.01	52.62	0.00	0.00
Maize cobs	350	None	3	15.55	24.73	43.62	69.36	0.00	0.00
Maize cobs	350	None	4	34.79	26.09	129.18	96.89	0.00	0.00
Maize cobs	550	None	1	20.57	29.83	47.38	68.70	0.35	0.50
Maize cobs	550	None	2	21.86	35.19	34.56	55.64	0.00	0.00
Maize cobs	550	None	3	22.58	38.15	42.84	72.41	0.00	0.00
Maize cobs	550	None	4	19.45	30.54	41.03	64.42	0.00	0.00
Maize cobs	350	Acetone	1	10.44	21.92	22.69	47.64	0.00	0.00
Maize cobs	350	Acetone	2	17.39	23.30	19.80	26.53	0.00	0.00
Maize cobs	350	Acetone	3	9.22	16.59	14.24	25.64	0.00	0.00
Maize cobs	350	Acetone	4	7.77	18.19	13.54	31.69	0.00	0.00
Maize cobs	550	Acetone	1	12.18	30.69	27.15	68.41	0.00	0.00
Maize cobs	550	Acetone	2						
Maize cobs	550	Acetone	3	10.72	21.98	15.50	31.77	0.00	0.00
Maize cobs	550	Acetone	4	10.05	23.62	17.09	40.17	0.00	0.00
Maize cobs	350	H_2O	1	6.01	12.08	8.99	18.07	0.00	0.00
Maize cobs	350	H_2O	2	9.19	14.34	17.63	27.50	0.45	0.70

Maize cobs	350	H_2O	3	2.74	4.80	9.05	15.83	0.00	0.00
Maize cobs	350	H_2O	4						
Maize cobs	550	H_2O	1	23.22	30.42	33.45	43.82	0.00	0.00
Maize cobs	550	H_2O	2	18.45	30.26	41.25	67.65	0.00	0.00
Maize cobs	550	H_2O	3	29.26	35.99	53.29	65.55	0.00	0.00
Maize cobs	550	H_2O	4	11.05	27.62	17.92	44.81	0.00	0.00
Maize cobs	350	HCL	1	14.98	31.31	13.38	27.97	0.00	0.00
Maize cobs	350	HCL	2	16.04	29.35	18.72	34.27	0.14	0.26
Maize cobs	350	HCL	3	24.12	41.97	15.70	27.32	0.13	0.22
Maize cobs	350	HCL	4	36.08	54.84	20.87	31.73	0.00	0.00
Maize cobs	550	HCL	1	39.16	49.73	74.01	94.00	0.28	0.36
Maize cobs	550	HCL	2	33.11	51.65	78.90	123.09	0.00	0.00
Maize cobs	550	HCL	3	35.06	61.00	24.80	43.15	0.00	0.00
Maize cobs	550	HCL	4	39.17	45.43	51.54	59.78	0.00	0.00
Maize cobs	350	None	1						
Maize cobs	350	None	2	19.25	36.38	28.03	52.97	0.00	0.00
Maize cobs	350	None	3	15.81	27.66	28.12	49.20	0.00	0.00
Maize cobs	350	None	4	15.97	35.14	17.31	38.08	0.00	0.00
Maize cobs	550	None	1	24.44	51.57	30.17	63.65	0.00	0.00
Maize cobs	550	None	2	17.60	43.46	31.27	77.25	0.00	0.00
Maize cobs	550	None	3	35.64	69.14	40.40	78.39	0.00	0.00
Maize cobs	550	None	4	32.62	55.77	46.56	79.62	0.00	0.00
Maize cobs	350	Acetone	1	9.83	24.37	21.40	53.07	0.00	0.00
Maize cobs	350	Acetone	2	66.59	27.30	118.92	48.76	0.48	0.20
Maize cobs	350	Acetone	3	22.97	28.94	70.13	88.37	0.12	0.16
Maize cobs	350	Acetone	4	20.37	35.85	23.47	41.31	0.29	0.51
Maize cobs	550	Acetone	1	30.14	33.15	77.71	85.48	0.33	0.36
Maize cobs	550	Acetone	2	14.69	29.08	100.00	197.99	0.05	0.10
Maize cobs	550	Acetone	3	14.88	29.31	31.20	61.46	0.06	0.12
Maize cobs	550	Acetone	4	15.37	28.90	175.89	330.67	0.00	0.00
Maize cobs	350	H_2O	1	22.69	37.44	56.71	93.56	0.19	0.31
Maize cobs	350	H_2O	2	17.61	32.40	30.00	55.20	0.00	0.00
Maize cobs	350	H_2O	3	15.54	36.68	19.03	44.90	0.02	0.05
Maize cobs	350	H_2O	4	13.31	31.55	17.16	40.67	0.01	0.03
Maize cobs	550	H_2O	1	40.42	31.93	144.23	113.94	0.02	0.01
Maize cobs	550	H_2O	2	19.18	42.20	37.53	82.56	0.16	0.36
Maize cobs	550	H_2O	3	11.22	34.66	41.29	127.58	0.00	0.00
Maize cobs	550	H_2O	4	27.68	44.57	50.39	81.13	0.04	0.06
Maize cobs	350	HCL	1	30.61	59.68	52.12	101.63	0.00	0.00

Maize cobs	350	HCL	2	30.48	71.33	27.84	65.15	0.08	0.18
Maize cobs	350	HCL	3						
Maize cobs	350	HCL	4	36.86	81.84	24.44	54.26	0.15	0.33
Maize cobs	550	HCL	1	85.12	81.71	60.55	58.13	0.15	0.14
Maize cobs	550	HCL	2	52.85	82.98	37.29	58.54	0.11	0.17
Maize cobs	550	HCL	3	51.46	71.02	63.71	87.91	0.25	0.35
Maize cobs	550	HCL	4	24.56	43.71	70.45	125.39	0.18	0.31
Eucalyptus	350	None	1	11.43	19.32	23.40	39.55	0.03	0.05
Eucalyptus	350	None	2	7.34	19.81	17.20	46.45	0.03	0.07
Eucalyptus	350	None	3	12.63	27.78	22.66	49.85	0.02	0.05
Eucalyptus	350	None	4	15.25	27.30	28.90	51.73	0.08	0.14
Eucalyptus	550	None	1	9.68	19.07	51.43	101.32	0.02	0.04
Eucalyptus	550	None	2	12.08	19.22	33.54	53.32	0.15	0.24
Eucalyptus	550	None	3	10.07	18.84	24.73	46.24	0.07	0.13
Eucalyptus	550	None	4	9.43	23.67	20.87	52.38	0.01	0.02
Eucalyptus	350	Acetone	1	7.57	13.17	12.67	22.04	0.06	0.11
Eucalyptus	350	Acetone	2	8.16	21.61	23.34	61.86	0.14	0.37
Eucalyptus	350	Acetone	3	9.83	17.10	16.05	27.93	0.06	0.11
Eucalyptus	350	Acetone	4	5.66	14.94	14.66	38.70	0.00	0.00
Eucalyptus	550	Acetone	1	31.42	29.22	246.45	229.20	0.00	0.00
Eucalyptus	550	Acetone	2	40.73	39.51	74.33	72.10	0.25	0.24
Eucalyptus	550	Acetone	3	20.41	34.91	48.03	82.13	0.07	0.12
Eucalyptus	550	Acetone	4	36.11	28.89	36.41	29.12	0.19	0.15
Eucalyptus	350	H_2O	1	12.35	15.69	37.62	47.78	0.08	0.10
Eucalyptus	350	H_2O	1	12.29	15.60	38.94	49.45	0.00	0.00
Eucalyptus	350	H_2O	2	9.49	17.64	12.00	22.32	0.00	0.00
Eucalyptus	350	H_2O	3	5.95	17.31	16.62	48.37	0.00	0.00
Eucalyptus	350	H_2O	4	14.39	26.05	17.61	31.87	0.09	0.16
Eucalyptus	550	H_2O	1	20.36	24.84	53.57	65.35	0.13	0.16
Eucalyptus	550	H_2O	2	68.26	58.02	145.27	123.48	0.12	0.10
Eucalyptus	550	H_2O	3	84.70	38.96	157.05	72.24	0.98	0.45
Eucalyptus	550	H_2O	4	9.67	17.41	35.37	63.67	0.03	0.06
Eucalyptus	350	HCL	1	23.77	46.10	33.51	65.02	0.07	0.13
Eucalyptus	350	HCL	2	32.03	53.81	25.25	42.41	0.05	0.08
Eucalyptus	350	HCL	3	22.82	43.35	24.00	45.60	0.01	0.01
Eucalyptus	350	HCL	4	30.98	58.85	18.13	34.44	0.00	0.00
Eucalyptus	550	HCL	1	38.09	50.27	92.22	121.73	0.17	0.23
Eucalyptus	550	HCL	2	22.68	46.94	27.96	57.87	0.00	0.00
Eucalyptus	550	HCL	3	42.86	52.71	47.41	58.31	0.16	0.20
Eucalyptus	550	HCL	4	23.43	42.18	26.15	47.08	0.06	0.10

Eucalyptus	350	None	1	9.87	20.33	16.77	34.55	0.11	0.24
Eucalyptus	350	None	2	11.28	27.29	60.50	146.41	0.11	0.27
Eucalyptus	350	None	3	13.55	31.44	52.54	121.90	0.08	0.18
Eucalyptus	350	None	4	25.35	36.50	47.51	68.41	0.11	0.16
Eucalyptus	550	None	1						
Eucalyptus	550	None	2	12.55	23.84	35.46	67.37	0.08	0.16
Eucalyptus	550	None	3	14.44	20.36	59.47	83.85	0.13	0.18
Eucalyptus	550	None	4	12.68	15.86	29.30	36.62	0.02	0.02
Eucalyptus	350	Acetone	1	13.67	22.43	36.53	59.90	0.00	0.00
Eucalyptus	350	Acetone	2	11.57	19.32	26.47	44.20	0.00	0.00
Eucalyptus	350	Acetone	3	9.01	21.53	20.35	48.63	0.00	0.00
Eucalyptus	350	Acetone	4	9.98	17.97	25.58	46.05	0.00	0.00
Eucalyptus	550	Acetone	1	7.42	21.06	15.24	43.28	0.00	0.00
Eucalyptus	550	Acetone	2	27.81	30.59	60.50	66.55	0.00	0.00
Eucalyptus	550	Acetone	3	9.31	26.43	84.38	239.65	0.00	0.00
Eucalyptus	550	Acetone	4	29.90	32.89	55.90	61.49	0.00	0.00
Eucalyptus	350	H_2O	1	8.00	20.17	14.92	37.60	0.00	0.00
Eucalyptus	350	H_2O	2	9.08	22.24	16.48	40.37	0.00	0.00
Eucalyptus	350	H_2O	3	-9.89	-21.46	223.31	484.58	0.00	0.00
Eucalyptus	350	H_2O	4	7.09	14.33	19.32	39.02	0.00	0.00
Eucalyptus	550	H_2O	1	6.75	15.18	11.29	25.39	0.00	0.00
Eucalyptus	550	H_2O	2	9.84	17.32	20.69	36.41	0.00	0.00
Eucalyptus	550	H_2O	3	10.17	17.90	21.53	37.90	0.00	0.00
Eucalyptus	550	H_2O	4	7.87	14.95	20.59	39.13	0.00	0.00
Eucalyptus	350	HCL	1	25.59	40.43	20.47	32.34	0.00	0.00
Eucalyptus	350	HCL	2	18.08	45.02	24.75	61.63	0.00	0.00
Eucalyptus	350	HCL	3	13.58	35.31	16.17	42.05	0.00	0.00
Eucalyptus	350	HCL	4	16.84	34.69	18.85	38.83	0.00	0.00
Eucalyptus	550	HCL	1	13.11	31.59	13.10	31.56	0.00	0.00
Eucalyptus	550	HCL	2	12.20	33.19	26.67	72.55	0.00	0.00
Eucalyptus	550	HCL	3	19.23	39.62	28.84	59.42	0.08	0.17
Eucalyptus	550	HCL	4	33.02	63.73	55.30	106.72	0.00	0.00
Delonix	350	None	1	26.20	19.65	52.09	39.07	0.00	0.00
Delonix	350	None	2	7.26	19.18	19.84	52.37	0.00	0.00
Delonix	350	None	3	12.86	23.91	19.88	36.98	0.00	0.00
Delonix	350	None	4	9.75	19.69	12.99	26.24	0.00	0.00
Delonix	550	None	1	13.01	25.11	21.51	41.51	0.00	0.00
Delonix	550	None	2	12.10	29.17	36.47	87.90	0.00	0.00
Delonix	550	None	3	12.07	26.91	17.87	39.86	0.00	0.00
Delonix	550	None	4	10.88	24.48	20.66	46.49	0.07	0.15
Delonix	350	Acetone	1	63.39	25.36	145.6	58.27	0.00	0.00

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Delonix	350	Acetone	2	35.21	45.77	29.86	38.82	0.00	0.00
Delonix	350	Acetone	3	7.34	16.80	26.30	60.23	0.00	0.00
Delonix	350	Acetone	4	10.10	24.64	29.99	73.17	0.00	0.00
Delonix	550	Acetone	1	7.27	22.19	16.42	50.08	0.00	0.00
Delonix	550	Acetone	2	8.11	22.71	15.63	43.77	0.00	0.00
Delonix	550	Acetone	3	17.21	27.87	28.74	46.55	0.09	0.14
Delonix	550	Acetone	4	9.60	25.15	20.92	54.81	0.00	0.00
Delonix	350	H_2O	1	7.86	21.23	16.44	44.40	0.00	0.00
Delonix	350	H_2O	2	18.18	29.09	37.94	60.71	0.00	0.00
Delonix	350	H_2O	3	8.51	18.71	13.51	29.72	0.00	0.00
Delonix	350	H_2O	4	8.31	24.52	25.75	75.96	0.00	0.00
Delonix	550	H_2O	1	11.38	28.45	38.38	95.95	0.00	0.00
Delonix	550	H_2O	1	10.99	27.47	36.54	91.35	0.00	0.00
Delonix	550	H_2O	2	17.96	29.46	44.17	72.44	0.00	0.00
Delonix	550	H_2O	3	36.99	50.30	191.35	260.23	0.00	0.00
Delonix	550	H_2O	4						
Delonix	350	HCL	1	30.27	57.52	21.96	41.73	0.00	0.00
Delonix	350	HCL	2	33.29	49.60	25.79	38.43	0.00	0.00
Delonix	350	HCL	3	18.80	32.90	25.54	44.69	0.00	0.00
Delonix	350	HCL	4	27.43	50.19	14.73	26.96	0.00	0.00
Delonix	550	HCL	1	23.60	41.76	27.88	49.36	0.12	0.20
Delonix	550	HCL	2	11.04	31.03	28.79	80.89	0.00	0.00
Delonix	550	HCL	3						
Delonix	550	HCL	4	20.47	40.12	27.31	53.52	0.00	0.00
Delonix	350	None	1	15.74	30.85	22.10	43.31	0.00	0.00
Delonix	350	None	1	15.13	29.65	21.90	42.92	0.00	0.00
Delonix	350	None	2	17.45	37.17	26.72	56.92	0.00	0.00
Delonix	350	None	2	17.96	38.25	28.54	60.78	0.00	0.00
Delonix	350	None	3	10.05	26.14	20.03	52.07	0.00	0.00
Delonix	350	None	3	9.81	25.51	17.09	44.42	0.06	0.15
Delonix	350	None	4	9.67	31.80	24.29	79.91	0.04	0.14
Delonix	350	None	4	9.90	32.58	24.34	80.09	0.00	0.00
Delonix	550	None	1	21.67	31.20	40.14	57.81	0.15	0.22
Delonix	550	None	2	16.78	32.56	54.31	105.36	0.00	0.00
Delonix	550	None	3	13.61	25.17	27.06		0.00	0.00
Delonix	550	None	4	20.63	33.22	37.70	60.70	0.38	0.61
Delonix	350	Acetone	1	12.97	29.44	20.47	46.47	0.00	0.00
Delonix	350	Acetone	2	12.75	24.85	14.17	27.64	0.00	0.00
Delonix	350	Acetone	3	16.14	26.14	18.20	29.49	0.00	0.00

Delonix	350	Acetone	4	9.53	16.87	14.72	26.06	0.14	0.24
Delonix	550	Acetone	1	20.76	39.44	48.93	92.96	0.00	0.00
Delonix	550	Acetone	2	27.82	29.21	46.86	49.20	0.20	0.21
Delonix	550	Acetone	3						
Delonix	550	Acetone	4	22.54	38.76	19.83	34.11	0.15	0.25
Delonix	350	H_2O	1	23.01	41.42	23.60	42.48	0.08	0.15
Delonix	350	H_2O	2	10.22	17.17	24.00	40.32	0.10	0.17
Delonix	350	H_2O	3						
Delonix	350	H_2O	4	21.56	35.80	25.53	42.37	0.10	0.17
Delonix	550	H_2O	1	15.99	27.98	31.59	55.28	0.00	0.00
Delonix	550	H_2O	2	26.27	48.33	123.56	227.34	0.13	0.25
Delonix	550	H_2O	3	27.61	42.80	104.42	161.85	0.00	0.00
Delonix	550	H_2O	4	36.21	63.73	31.83	56.02	0.00	0.00
Delonix	350	HCL	1	22.58	32.29	19.54	27.95	0.16	0.22
Delonix	350	HCL	2	37.05	64.10	18.06	31.24	0.37	0.64
Delonix	350	HCL	3	38.45	68.44	61.71	109.85	0.00	0.00
Delonix	350	HCL	4	47.74	89.27	29.41	54.99	0.17	0.32
Delonix	550	HCL	1						
Delonix	550	HCL	2	60.75	94.76	70.40	109.82	0.11	0.16
Delonix	550	HCL	3						
Delonix	550	HCL	4						
Tea	350	None	1	10.58	20.74	22.26	43.63	0.00	0.00
Tea	350	None	2	11.71	28.21	19.52	47.03	0.05	0.13
Tea	350	None	3	6.94	23.81	11.63	39.89	0.00	0.00
Tea	350	None	4	12.23	20.05	32.85	53.88	0.00	0.00
Tea	550	None	1	12.29	19.91	32.44	52.56	0.00	0.00
Tea	550	None	2	22.92	33.23	40.52	58.76	0.12	0.18
Tea	550	None	3	12.08	22.95	24.04	45.67	0.00	0.00
Tea	550	None	4	9.13	25.10	12.28	33.77	0.00	0.00
Tea	350	Acetone	1	11.39	16.74	27.45	40.36	0.00	0.00
Tea	350	Acetone	2	10.35	17.18	19.59	32.52	0.00	0.00
Tea	350	Acetone	3	7.64	18.80	14.71	36.18	0.00	0.00
Tea	350	Acetone	4	7.13	19.33	9.66	26.18	0.00	0.00
Tea	550	Acetone	1	25.32	34.94	59.68	82.36	0.00	0.00
Tea	550	Acetone	2	13.69	27.78	32.20	65.37	0.00	0.00
Tea	550	Acetone	3	12.92	24.03	14.07	26.17	0.00	0.00
Tea	550	Acetone	4	11.67	25.32	33.08	71.79	0.00	0.00
Tea	350	H_2O	1	8.83	20.49	13.95	32.35	0.00	0.00
Tea	350	H_2O	2						
Tea	350	H_2O	3	26.93	22.35	53.10	44.07	0.00	0.00

Tea	350	H_2O	4	10.41	19.47	26.32	49.22	0.00	0.00
Tea	550	H_2O	1	15.43	27.32	65.06	115.16	0.00	0.00
Tea	550	H_2O	2	23.21	19.03	55.92	45.85	0.00	0.00
Tea	550	H_2O	3	9.00	23.58	18.66	48.89	0.00	0.00
Tea	550	H_2O	4	16.26	24.07	39.37	58.27	0.00	0.00
Tea	350	HCL	1	23.47	39.20	27.10	45.25	0.00	0.00
Tea	350	HCL	2	26.57	34.54	30.00	39.00	0.00	0.00
Tea	350	HCL	3	18.36	31.39	22.11	37.81	0.00	0.00
Tea	350	HCL	4	22.27	28.28	31.51	40.02	0.22	0.28
Tea	550	HCL	1	27.93	47.76	118.04	201.85	0.15	0.25
Tea	550	HCL	2	14.83	29.22	22.09	43.52	0.12	0.24
Tea	550	HCL	3	15.24	27.43	38.62	69.52	0.07	0.13
Tea	550	HCL	4	22.01	37.64	31.21	53.36	0.07	0.12
Tea	350	None	1	17.79	26.33	31.71	46.94	0.16	0.24
Tea	350	None	2	18.15	29.59	22.05	35.94	0.04	0.06
Tea	350	None	3	12.53	30.32	16.88	40.84	0.03	0.08
Tea	350	None	4						
Tea	550	None	1	15.99	33.90	43.64	92.51	0.06	0.13
Tea	550	None	2	13.86	32.44	21.57	50.47	0.05	0.11
Tea	550	None	3	34.82	44.92	65.89	84.99	0.35	0.45
Tea	550	None	4						
Tea	350	Acetone	1	16.10	26.40	21.74	35.65	0.00	0.00
Tea	350	Acetone	2	15.94	27.58	30.43	52.65	0.00	0.00
Tea	350	Acetone	3	18.32	29.86	26.15	42.63	0.05	0.09
Tea	350	Acetone	4	19.52	24.41	28.56	35.70	0.16	0.20
Tea	550	Acetone	1	25.34	30.91	30.80	37.57	0.00	0.00
Tea	550	Acetone	2	15.72	22.80	43.07	62.45	0.18	0.27
Tea	550	Acetone	3	19.41	26.21	32.44	43.79	0.08	0.11
Tea	550	Acetone	4	27.66	33.20	52.66	63.19	0.18	0.22
Tea	350	H_2O	1	7.60	20.53	12.01	32.43	0.03	0.09
Tea	350	H_2O	2	10.80	25.92	16.06	38.56	0.05	0.13
Tea	350	H_2O	3	18.22	25.51	33.21	46.50	0.11	0.16
Tea	350	H_2O	4	15.63	26.73	16.70	28.56	0.05	0.08
Tea	550	H_2O	1	20.82	38.52	24.22	44.82	0.07	0.13
Tea	550	H_2O	2	15.33	34.19	23.83	53.14	0.00	0.00
Tea	550	H_2O	3	12.35	24.69	20.14	40.28	0.13	0.26
Tea	550	H_2O	4	26.75	46.28	26.84	46.43	0.00	0.00
Tea	350	HCL	1	16.35	36.61	11.74	26.31	0.03	0.07
Tea	350	HCL	2	101.28	88.12	71.93	62.58	0.37	0.32
Tea	350	HCL	3	9.00	30.60	11.64	39.58	0.05	0.16

Tea	350	HCL	4	9.19	23.70	18.11	46.73	0.05	0.13
Tea	550	HCL	1	39.16	50.12	49.06	62.79	0.19	0.24
Tea	550	HCL	2	35.30	55.77	46.81	73.95	0.00	0.00
Tea	550	HCL	3						
Tea	550	HCL	4	66.00	77.88	47.19	55.68	0.39	0.46

Table 3.S9. Data from chapter 1 table 1.4.

Feedstock	Temp (°C)	Treatment	Rep	Cu (mg g^{-1})	Cu (mg $plant^{-1}$)	Zn (mg g^{-1})	Zn (mg $plant^{-1}$)	As (mg g^{-1})	As (mg $plant^{-1}$)
Rice	350	None	1	0.42	0.65	2.65	4.06	0.00	0.00
Rice	350	None	2	0.35	0.70	2.09	4.12	0.00	0.00
Rice	350	None	3	0.59	0.68	3.81	4.42	0.00	0.00
Rice	350	None	4	0.42	0.71	2.36	3.97	0.00	0.00
Rice	550	None	1	0.43	0.88	2.55	5.23	0.00	0.00
Rice	550	None	2	0.32	0.86	2.07	5.53	0.00	0.00
Rice	550	None	3	0.31	0.90	2.12	6.05	0.00	0.00
Rice	550	None	4	32.83	38.09	9.59	11.13	0.00	0.00
Rice	350	Acetone	1	0.28	0.58	1.90	3.93	0.00	0.00
Rice	350	Acetone	2	0.53	0.58	4.90	5.39	0.00	0.00
Rice	350	Acetone	3	0.25	0.67	1.76	4.75	0.00	0.00
Rice	350	Acetone	4	1.00	1.02	4.03	4.12	0.00	0.00
Rice	550	Acetone	1	0.46	1.16	2.97	7.48	0.00	0.00
Rice	550	Acetone	2	0.58	1.23	3.17	6.68	0.00	0.00
Rice	550	Acetone	3						
Rice	550	Acetone	4	0.61	1.43	3.47	8.15	0.00	0.00
Rice	350	H_2O	1	0.25	0.57	1.65	3.79	0.00	0.00
Rice	350	H_2O	2	0.32	0.77	2.94	6.94	0.00	0.00
Rice	350	H_2O	3	0.36	0.62	2.60	4.52	0.00	0.00
Rice	350	H_2O	4	0.25	0.66	2.91	7.56	0.00	0.00
Rice	550	H_2O	1	0.50	1.04	5.50	11.44	0.00	0.00
Rice	550	H_2O	2	0.46	0.93	3.78	7.64	0.00	0.00
Rice	550	H_2O	3	0.50	0.93	3.40	6.33	0.00	0.00
Rice	550	H_2O	4	0.30	0.87	2.78	8.08	0.00	0.00
Rice	350	HCL	1	0.46	0.79	4.42	7.51	0.00	0.00
Rice	350	HCL	2	0.23	0.64	1.80	5.03	0.00	0.00
Rice	350	HCL	3	0.49	0.79	4.65	7.49	0.00	0.00
Rice	350	HCL	4	0.33	0.90	5.07	13.59	0.00	0.00
Rice	550	HCL	1	0.59	1.08	4.15	7.56	0.00	0.00

Rice	550	HCL	1	0.57	1.03	4.08	7.42	0.00	0.00
Rice	550	HCL	2	0.70	1.40	4.27	8.53	0.00	0.00
Rice	550	HCL	3	0.64	1.27	4.56	9.07	0.00	0.00
Rice	550	HCL	4	0.37	0.95	2.89	7.33	0.00	0.00
Rice	350	None	1	0.36	0.82	2.80	6.42	0.00	0.00
Rice	350	None	2	0.32	0.76	3.02	7.32	0.00	0.00
Rice	350	None	3	0.35	0.82	2.33	5.52	0.00	0.00
Rice	350	None	4	0.26	0.71	2.66	7.22	0.00	0.00
Rice	550	None	1	0.45	1.06	3.38	8.01	0.00	0.00
Rice	550	None	2	1.09	1.45	10.10	13.53	0.00	0.00
Rice	550	None	3	0.52	1.20	4.02	9.33	0.00	0.00
Rice	550	None	4						
Rice	350	Acetone	1	0.45	0.76	3.85	6.54	0.00	0.00
Rice	350	Acetone	2	0.33	0.67	3.32	6.77	0.00	0.00
Rice	350	Acetone	3	0.42	0.75	3.22	5.76	0.00	0.00
Rice	350	Acetone	4	2.36	4.85	6.08	12.47	0.00	0.00
Rice	550	Acetone	1	1.77	1.84	9.21	9.58	0.00	0.00
Rice	550	Acetone	2	0.69	1.22	5.13	9.14	0.00	0.00
Rice	550	Acetone	3	0.42	0.94	3.42	7.60	0.00	0.00
Rice	550	Acetone	4	0.68	1.07	5.14	8.01	0.00	0.00
Rice	550	Acetone	4						
Rice	350	H_2O	1	-16.16	-35.38	-66.60	-145.86	0.00	0.00
Rice	350	H_2O	2	0.37	0.85	2.83	6.47	0.00	0.00
Rice	350	H_2O	3	0.37	0.77	2.72	5.62	0.00	0.00
Rice	350	H_2O	4	0.33	0.82	2.41	6.04	0.00	0.00
Rice	550	H_2O	1	0.47	1.03	4.07	8.95	0.00	0.00
Rice	550	H_2O	2	0.43	1.07	3.13	7.75	0.00	0.00
Rice	550	H_2O	3	0.52	1.03	4.64	9.19	0.00	0.00
Rice	550	H_2O	4	0.61	0.96	5.35	8.46	0.00	0.00
Rice	350	HCL	1	0.37	0.89	2.00	4.85	0.00	0.00
Rice	350	HCL	2	0.00	0.00	0.45	1.33	2.16	6.46
Rice	350	HCL	3	0.09	0.21	0.44	1.07	2.38	5.85
Rice	350	HCL	4	0.00	0.00	1.58	1.18	8.69	6.51
Rice	550	HCL	1	0.00	0.00	2.06	2.89	7.41	10.38
Rice	550	HCL	2	0.22	0.25	1.28	1.43	9.68	10.84
Rice	550	HCL	3	0.00	0.00	0.64	1.65	3.14	8.05
Rice	550	HCL	4	0.00	0.00	0.58	1.57	2.89	7.77
Bagasse	350	None	1	0.00	0.00	0.55	0.88	3.26	5.16
Bagasse	350	None	2	0.00	0.00	0.21	0.46	1.88	4.12
Bagasse	350	None	3	0.00	0.00	0.18	0.44	1.57	3.91
Bagasse	350	None	4	0.00	0.00	0.19	0.44	1.68	3.78

Bagasse	550	None	1	0.00	0.00	0.38	0.69	2.70	4.92
Bagasse	550	None	2	0.00	0.00	0.30	0.51	2.85	4.78
Bagasse	550	None	3	0.00	0.00	0.18	0.46	1.85	4.86
Bagasse	550	None	4	0.00	0.00	0.64	0.48	11.13	8.23
Bagasse	350	Acetone	1	0.00	0.00	0.15	0.29	1.67	3.28
Bagasse	350	Acetone	2	0.31	0.34	0.42	0.47	4.20	4.62
Bagasse	350	Acetone	3	0.15	0.36	0.64	1.52	1.54	3.64
Bagasse	350	Acetone	4	0.06	0.13	0.40	0.89	1.51	3.40
Bagasse	550	Acetone	1	0.00	0.00	0.41	1.08	1.62	4.26
Bagasse	550	Acetone	2	0.00	0.00	0.40	0.94	3.50	8.25
Bagasse	550	Acetone	2	0.00	0.00	0.47	1.10	1.97	4.65
Bagasse	550	Acetone	3	0.00	0.00	0.78	1.09	3.37	4.75
Bagasse	550	Acetone	4	0.00	0.00	0.62	1.59	2.15	5.46
Bagasse	350	H_2O	1	0.00	0.00	0.41	0.75	2.11	3.83
Bagasse	350	H_2O	2	0.00	0.00	0.50	0.73	2.99	4.31
Bagasse	350	H_2O	3	0.00	0.00	0.43	0.69	2.20	3.52
Bagasse	350	H_2O	4	0.00	0.00	0.35	0.70	1.98	3.96
Bagasse	550	H_2O	1	0.00	0.00	2.39	2.82	3.91	4.62
Bagasse	550	H_2O	2	0.00	0.00	0.79	1.07	3.02	4.11
Bagasse	550	H_2O	3	0.00	0.00	0.34	1.03	1.46	4.38
Bagasse	550	H_2O	4	0.00	0.00	0.42	1.05	2.05	5.12
Bagasse	350	HCL	1	0.00	0.00	0.39	0.81	2.25	4.62
Bagasse	350	HCL	2	0.04	0.03	0.98	0.82	8.94	7.42
Bagasse	350	HCL	3	0.00	0.00	0.41	0.98	2.70	6.40
Bagasse	350	HCL	4	0.03	0.07	0.46	1.00	3.19	6.98
Bagasse	550	HCL	1	0.00	0.00	1.33	1.24	10.06	9.36
Bagasse	550	HCL	2	0.09	0.09	1.39	1.34	6.55	6.29
Bagasse	550	HCL	3	0.00	0.00	1.63	2.31	4.30	6.11
Bagasse	550	HCL	4	0.00	0.00	0.76	1.27	3.14	5.21
Bagasse	350	None	1	0.00	0.00	0.29	0.70	1.79	4.29
Bagasse	350	None	2	0.00	0.00	0.97	1.84	2.29	4.38
Bagasse	350	None	3	0.11	0.26	0.38	0.92	1.92	4.61
Bagasse	350	None	4	0.11	0.19	0.58	0.99	2.62	4.48
Bagasse	550	None	1	0.00	0.00	0.96	1.21	6.32	7.97
Bagasse	550	None	2	0.00	0.00	0.65	1.43	4.32	9.46
Bagasse	550	None	3	0.00	0.00	0.48	1.03	3.09	6.59
Bagasse	550	None	4	0.00	0.00	1.59	1.62	6.96	7.10
Bagasse	350	Acetone	1	0.04	0.08	0.40	0.72	2.62	4.73
Bagasse	350	Acetone	2	0.07	0.11	0.53	0.81	2.97	4.51
Bagasse	350	Acetone	3	0.00	0.00	0.32	0.80	1.83	4.60
Bagasse	350	Acetone	4	0.00	0.00	0.57	0.79	5.29	7.36

Bagasse	550	Acetone	1	0.03	0.06	0.85	1.44	4.09	6.95
Bagasse	550	Acetone	2	0.06	0.13	0.55	1.11	3.54	7.07
Bagasse	550	Acetone	3	0.16	0.14	1.45	1.25	10.43	8.97
Bagasse	550	Acetone	4	0.00	0.00	0.67	1.26	4.13	7.76
Bagasse	350	H_2O	1	0.03	0.07	0.30	0.68	1.89	4.34
Bagasse	350	H_2O	2	0.00	0.00	0.91	0.84	4.52	4.15
Bagasse	350	H_2O	3						
Bagasse	350	H_2O	4	1.19	1.00	8.92	7.49	0.15	0.12
Bagasse	550	H_2O	1	1.13	1.43	9.35	11.88	0.20	0.25
Bagasse	550	H_2O	2	0.57	1.21	3.23	6.87	0.00	0.00
Bagasse	550	H_2O	3	4.14	1.24	40.66	12.20	0.00	0.00
Bagasse	550	H_2O	4	1.11	1.37	4.92	6.10	0.19	0.23
Bagasse	350	HCL	1	0.43	0.96	2.57	5.80	0.00	0.00
Bagasse	350	HCL	1						
Bagasse	350	HCL	2						
Bagasse	350	HCL	3	0.54	0.99	3.50	6.34	0.00	0.00
Bagasse	350	HCL	4	0.60	1.00	2.55	4.22	0.00	0.00
Bagasse	550	HCL	1	0.89	1.45	4.51	7.35	0.00	0.00
Bagasse	550	HCL	2	0.80	1.60	5.21	10.41	0.24	0.48
Bagasse	550	HCL	3	1.56	1.95	9.01	11.26	0.00	0.00
Bagasse	550	HCL	4	0.75	1.36	3.42	6.19	0.09	0.17
Maize stovers	350	None	1	0.66	0.86	2.63	3.45	0.14	0.18
Maize stovers	350	None	2	0.48	0.87	2.10	3.84	0.08	0.15
Maize stovers	350	None	3	0.39	0.75	1.69	3.27	0.10	0.19
Maize stovers	350	None	4	0.52	0.77	2.43	3.60	0.00	0.00
Maize stovers	550	None	1						
Maize stovers	550	None	2	1.28	1.03	6.43	5.21	0.00	0.00
Maize stovers	550	None	3	0.70	1.09	3.24	5.03	0.17	0.27
Maize stovers	550	None	4	1.16	1.14	7.42	7.28	0.27	0.27
Maize stovers	350	Acetone	1	0.44	0.78	1.63	2.89	0.06	0.10
Maize stovers	350	Acetone	2	0.38	0.85	1.30	2.89	0.00	0.00
Maize stovers	350	Acetone	3	0.32	0.72	1.43	3.17	0.00	0.00
Maize stovers	350	Acetone	4	0.36	0.71	1.46	2.90	0.00	0.00
Maize stovers	550	Acetone	1	0.67	1.09	3.15	5.14	0.00	0.00
Maize stovers	550	Acetone	2	0.53	1.05	2.52	5.02	0.00	0.00
Maize stovers	550	Acetone	3	1.19	0.96	9.76	7.81	0.00	0.00
Maize stovers	550	Acetone	4	0.40	1.24	1.63	5.08	0.00	0.00
Maize stovers	350	H_2O	1	0.37	0.77	1.58	3.31	0.09	0.20
Maize stovers	350	H_2O	2	0.51	0.76	2.95	4.37	0.00	0.00
Maize stovers	350	H_2O	3	0.40	0.76	1.85	3.51	0.00	0.00

Maize stovers	350	H_2O	4						
Maize stovers	550	H_2O	1	0.55	0.91	3.55	5.89	0.00	0.00
Maize stovers	550	H_2O	2	1.69	1.52	7.12	6.40	0.25	0.23
Maize stovers	550	H_2O	3	0.54	1.07	2.74	5.36	0.00	0.00
Maize stovers	550	H_2O	4	0.77	1.06	3.29	4.54	0.00	0.00
Maize stovers	350	HCL	1	0.80	1.06	5.75	7.60	0.00	0.00
Maize stovers	350	HCL	2	0.60	0.98	4.08	6.69	0.00	0.00
Maize stovers	350	HCL	3	0.55	0.98	4.49	7.91	0.00	0.00
Maize stovers	350	HCL	4	0.52	1.02	3.14	6.18	0.21	0.41
Maize stovers	550	HCL	1	0.62	1.30	3.42	7.23	0.00	0.00
Maize stovers	550	HCL	2	0.63	1.32	3.32	6.97	0.00	0.00
Maize stovers	550	HCL	3	0.87	1.49	4.62	7.85	0.12	0.20
Maize stovers	550	HCL	4	1.44	1.68	9.26	10.84	0.15	0.18
Maize stovers	350	None	1	0.80	1.43	2.38	4.24	0.00	0.00
Maize stovers	350	None	2	0.39	1.06	1.66	4.55	0.05	0.15
Maize stovers	350	None	3	0.40	1.04	1.56	4.03	0.00	0.00
Maize stovers	350	None	4	0.44	0.88	2.19	4.43	0.00	0.00
Maize stovers	550	None	1	1.10	1.34	6.54	7.92	0.00	0.00
Maize stovers	550	None	2	0.76	1.63	2.81	6.04	0.00	0.00
Maize stovers	550	None	3	1.10	1.93	4.27	7.48	0.07	0.13
Maize stovers	550	None	4	0.81	1.37	4.67	7.89	0.13	0.23
Maize stovers	350	Acetone	1	0.43	0.98	2.12	4.81	0.00	0.00
Maize stovers	350	Acetone	2	0.95	1.32	4.05	5.63	0.13	0.19
Maize stovers	350	Acetone	3	0.69	1.08	3.30	5.18	0.00	0.00
Maize stovers	350	Acetone	4	0.76	1.39	2.43	4.44	0.07	0.13
Maize stovers	550	Acetone	1	1.19	1.65	5.82	8.09	0.00	0.00
Maize stovers	550	Acetone	2	1.21	1.63	5.16	6.91	0.00	0.00
Maize stovers	550	Acetone	3	0.82	1.36	4.69	7.82	0.08	0.13
Maize stovers	550	Acetone	4	2.84	1.79	15.00	9.45	0.36	0.23
Maize stovers	350	H_2O	1	2.37	1.14	11.40	5.47	0.44	0.21
Maize stovers	350	H_2O	2	0.42	0.82	2.53	4.89	0.12	0.22
Maize stovers	350	H_2O	3	0.49	0.85	2.45	4.32	0.17	0.31
Maize stovers	350	H_2O	4	5.00	1.00	23.16	4.63	0.56	0.11
Maize stovers	550	H_2O	1	0.73	1.36	3.74	6.95	0.12	0.23
Maize stovers	550	H_2O	2	1.09	1.72	4.83	7.63	0.18	0.28
Maize stovers	550	H_2O	3	1.40	1.57	6.83	7.64	0.29	0.32
Maize stovers	550	H_2O	4	0.57	1.50	3.16	8.27	0.17	0.44
Maize stovers	350	HCL	1	0.62	1.05	3.89	6.57	0.24	0.40
Maize stovers	350	HCL	2						
Maize stovers	350	HCL	3						

Maize stovers	350	HCL	4	0.89	1.41	4.17	6.59	0.00	0.00
Maize stovers	550	HCL	1	1.00	1.76	6.11	10.76	0.31	0.54
Maize stovers	550	HCL	2	1.39	1.68	8.81	10.66	0.50	0.60
Maize stovers	550	HCL	3	1.41	1.98	6.15	8.61	0.37	0.51
Maize stovers	550	HCL	4	1.72	2.08	7.93	9.59	0.45	0.55
Maize cobs	350	None	1	0.69	1.13	2.44	3.99	0.10	0.16
Maize cobs	350	None	2	0.32	0.85	1.53	4.02	0.00	0.00
Maize cobs	350	None	3	0.70	1.12	2.94	4.68	0.00	0.00
Maize cobs	350	None	4	1.16	0.87	6.61	4.95	0.29	0.21
Maize cobs	550	None	1	0.88	1.28	4.66	6.76	0.00	0.00
Maize cobs	550	None	2	0.78	1.25	3.50	5.64	0.28	0.45
Maize cobs	550	None	3	0.89	1.50	4.18	7.06	0.22	0.37
Maize cobs	550	None	4	0.80	1.26	3.06	4.80	0.19	0.29
Maize cobs	350	Acetone	1	0.43	0.90	1.63	3.43	0.19	0.40
Maize cobs	350	Acetone	2	0.69	0.92	3.01	4.03	0.24	0.33
Maize cobs	350	Acetone	3	0.46	0.84	1.61	2.89	0.08	0.14
Maize cobs	350	Acetone	4	0.34	0.80	1.38	3.24	0.14	0.33
Maize cobs	550	Acetone	1	0.49	1.23	1.86	4.70	0.12	0.31
Maize cobs	550	Acetone	2						
Maize cobs	550	Acetone	3	0.52	1.07	2.11	4.33	0.17	0.36
Maize cobs	550	Acetone	4	0.81	1.90	1.88	4.41	0.08	0.20
Maize cobs	350	H_2O	1	0.45	0.91	2.07	4.17	0.11	0.23
Maize cobs	350	H_2O	2	0.70	1.09	3.12	4.87	0.15	0.23
Maize cobs	350	H_2O	3	0.57	1.00	2.64	4.62	0.13	0.22
Maize cobs	350	H_2O	4						
Maize cobs	550	H_2O	1	1.13	1.48	3.85	5.05	0.16	0.21
Maize cobs	550	H_2O	2	0.81	1.34	3.20	5.25	0.15	0.25
Maize cobs	550	H_2O	3	1.83	2.25	8.10	9.97	0.23	0.29
Maize cobs	550	H_2O	4	0.46	1.15	1.86	4.66	0.00	0.00
Maize cobs	350	HCL	1	0.43	0.90	2.27	4.75	0.00	0.00
Maize cobs	350	HCL	2	0.59	1.09	2.78	5.09	0.13	0.23
Maize cobs	350	HCL	3	0.60	1.04	2.87	4.99	0.14	0.25
Maize cobs	350	HCL	4	0.62	0.95	3.41	5.18	0.14	0.21
Maize cobs	550	HCL	1	1.27	1.61	7.55	9.59	0.04	0.05
Maize cobs	550	HCL	2	0.94	1.46	4.58	7.15	0.21	0.32
Maize cobs	550	HCL	3	0.76	1.31	4.12	7.17	0.25	0.43
Maize cobs	550	HCL	4	1.36	1.58	7.04	8.17	0.00	0.00
Maize cobs	350	None	1						
Maize cobs	350	None	2	0.91	1.73	6.53	12.35	0.15	0.28
Maize cobs	350	None	3	0.85	1.49	2.74	4.80	0.10	0.17
Maize cobs	350	None	4	0.49	1.08	2.12	4.66	0.07	0.16

Maize cobs	550	None	1	0.70	1.48	3.53	7.44	0.00	0.00
Maize cobs	550	None	2	0.58	1.44	2.68	6.63	0.08	0.19
Maize cobs	550	None	3	1.09	2.11	5.19	10.07	0.25	0.49
Maize cobs	550	None	4	0.89	1.52	3.84	6.56	0.24	0.42
Maize cobs	350	Acetone	1	0.40	0.99	1.62	4.03	0.12	0.30
Maize cobs	350	Acetone	2	2.26	0.93	12.67	5.19	0.00	0.00
Maize cobs	350	Acetone	3	0.85	1.07	4.44	5.59	0.00	0.00
Maize cobs	350	Acetone	4	0.69	1.21	3.48	6.13	0.00	0.00
Maize cobs	550	Acetone	1	1.68	1.85	7.09	7.79	0.00	0.00
Maize cobs	550	Acetone	2	0.69	1.37	3.43	6.79	0.00	0.00
Maize cobs	550	Acetone	3	0.77	1.52	4.04	7.95	0.00	0.00
Maize cobs	550	Acetone	4	0.80	1.50	4.27	8.02	0.00	0.00
Maize cobs	350	H_2O	1	0.51	0.84	2.77	4.57	0.00	0.00
Maize cobs	350	H_2O	2	0.54	0.99	2.58	4.74	0.00	0.00
Maize cobs	350	H_2O	3	0.51	1.21	2.36	5.56	0.00	0.00
Maize cobs	350	H_2O	4	0.62	1.46	2.47	5.85	0.00	0.00
Maize cobs	550	H_2O	1	2.81	2.22	10.04	7.93	0.49	0.39
Maize cobs	550	H_2O	2	0.70	1.54	4.10	9.02	0.17	0.36
Maize cobs	550	H_2O	3	0.45	1.40	2.09	6.44	0.00	0.00
Maize cobs	550	H_2O	4	0.98	1.58	4.48	7.22	0.00	0.00
Maize cobs	350	HCL	1	0.60	1.16	3.30	6.44	0.00	0.00
Maize cobs	350	HCL	2	0.48	1.13	2.94	6.89	0.00	0.00
Maize cobs	350	HCL	3						
Maize cobs	350	HCL	4	0.56	1.24	3.48	7.73	0.13	0.30
Maize cobs	550	HCL	1	1.74	1.67	9.67	9.28	0.00	0.00
Maize cobs	550	HCL	2	1.00	1.58	5.77	9.06	0.00	0.00
Maize cobs	550	HCL	3	1.17	1.61	6.51	8.98	0.00	0.00
Maize cobs	550	HCL	4	0.87	1.55	4.78	8.51	0.00	0.00
Eucalyptus	350	None	1	0.49	0.82	2.09	3.54	0.00	0.00
Eucalyptus	350	None	2	0.32	0.86	1.33	3.60	0.00	0.00
Eucalyptus	350	None	3	0.39	0.85	1.65	3.62	0.00	0.00
Eucalyptus	350	None	4	0.47	0.84	2.17	3.88	0.15	0.26
Eucalyptus	550	None	1	0.70	1.38	2.36	4.65	0.00	0.00
Eucalyptus	550	None	2	0.76	1.21	3.33	5.29	0.00	0.00
Eucalyptus	550	None	3	0.66	1.24	2.46	4.60	0.00	0.00
Eucalyptus	550	None	4	0.52	1.31	1.95	4.89	0.00	0.00
Eucalyptus	350	Acetone	1	0.55	0.96	2.08	3.63	0.00	0.00
Eucalyptus	350	Acetone	2	0.31	0.83	1.45	3.85	0.09	0.23
Eucalyptus	350	Acetone	3	0.51	0.90	2.10	3.66	0.00	0.00
Eucalyptus	350	Acetone	4	0.29	0.78	1.38	3.65	0.00	0.00
Eucalyptus	550	Acetone	1	2.18	2.03	6.56	6.10	0.00	0.00

Eucalyptus	550	Acetone	2	1.34	1.30	5.99	5.81	0.00	0.00
Eucalyptus	550	Acetone	3	0.91	1.55	3.09	5.28	0.00	0.00
Eucalyptus	550	Acetone	4	1.54	1.23	6.33	5.06	0.00	0.00
Eucalyptus	350	H_2O	1	0.69	0.87	3.03	3.84	0.00	0.00
Eucalyptus	350	H_2O	1	0.65	0.83	3.04	3.86	0.19	0.24
Eucalyptus	350	H_2O	2	0.39	0.73	1.90	3.53	0.17	0.32
Eucalyptus	350	H_2O	3	0.29	0.86	1.19	3.45	0.00	0.00
Eucalyptus	350	H_2O	4	0.51	0.92	2.24	4.05	0.00	0.00
Eucalyptus	550	H_2O	1	0.87	1.07	4.59	5.61	0.00	0.00
Eucalyptus	550	H_2O	2	1.97	1.67	16.21	13.78	0.00	0.00
Eucalyptus	550	H_2O	3	4.98	2.29	19.91	9.16	0.00	0.00
Eucalyptus	550	H_2O	4	0.61	1.09	3.62	6.52	0.00	0.00
Eucalyptus	350	HCL	1	0.49	0.96	2.97	5.77	0.11	0.22
Eucalyptus	350	HCL	2	0.51	0.85	3.05	5.12	0.00	0.00
Eucalyptus	350	HCL	3	0.48	0.92	2.60	4.93	0.00	0.00
Eucalyptus	350	HCL	4	0.50	0.94	2.62	4.97	0.00	0.00
Eucalyptus	550	HCL	1	1.43	1.88	6.40	8.45	0.00	0.00
Eucalyptus	550	HCL	2	0.68	1.40	4.03	8.33	0.00	0.00
Eucalyptus	550	HCL	3	1.35	1.66	8.24	10.13	0.00	0.00
Eucalyptus	550	HCL	4	0.89	1.59	3.62	6.52	0.00	0.00
Eucalyptus	350	None	1	0.53	1.10	2.02	4.16	0.00	0.00
Eucalyptus	350	None	2	0.37	0.90	2.19	5.31	0.00	0.00
Eucalyptus	350	None	3	0.41	0.95	1.97	4.58	0.00	0.00
Eucalyptus	350	None	4	0.64	0.92	3.80	5.47	0.18	0.26
Eucalyptus	550	None	1						
Eucalyptus	550	None	2	0.84	1.61	3.37	6.41	0.00	0.00
Eucalyptus	550	None	3	1.21	1.71	5.01	7.06	0.00	0.00
Eucalyptus	550	None	4	1.08	1.35	5.37	6.71	0.17	0.21
Eucalyptus	350	Acetone	1	0.60	0.99	2.79	4.58	0.00	0.00
Eucalyptus	350	Acetone	2	0.59	0.99	2.49	4.16	0.00	0.00
Eucalyptus	350	Acetone	3	0.52	1.23	2.24	5.36	0.00	0.00
Eucalyptus	350	Acetone	4	0.53	0.96	2.48	4.46	0.00	0.00
Eucalyptus	550	Acetone	1	0.53	1.50	2.31	6.56	0.00	0.00
Eucalyptus	550	Acetone	2	2.20	2.42	7.00	7.70	0.00	0.00
Eucalyptus	550	Acetone	3	0.43	1.22	2.48	7.04	0.00	0.00
Eucalyptus	550	Acetone	4	1.37	1.51	6.67	7.34	0.00	0.00
Eucalyptus	350	H_2O	1	0.39	0.98	2.01	5.06	0.00	0.00
Eucalyptus	350	H_2O	2	0.40	0.97	1.98	4.86	0.00	0.00
Eucalyptus	350	H_2O	3	1.45	3.14	-30.68	-66.58	0.00	0.00
Eucalyptus	350	H_2O	4	0.60	1.21	2.15	4.35	0.00	0.00

Eucalyptus	550	H_2O	1	0.53	1.18	2.40	5.41	0.00	0.00
Eucalyptus	550	H_2O	2	0.76	1.33	3.32	5.84	0.00	0.00
Eucalyptus	550	H_2O	3	0.66	1.16	3.30	5.80	0.00	0.00
Eucalyptus	550	H_2O	4	0.89	1.69	3.51	6.66	0.00	0.00
Eucalyptus	350	HCL	1	0.73	1.15	3.39	5.36	0.00	0.00
Eucalyptus	350	HCL	2	0.39	0.98	2.26	5.63	0.00	0.00
Eucalyptus	350	HCL	3	0.60	1.57	2.16	5.62	0.00	0.00
Eucalyptus	350	HCL	4	0.53	1.09	2.83	5.82	0.00	0.00
Eucalyptus	550	HCL	1	1.07	2.58	3.08	7.41	0.00	0.00
Eucalyptus	550	HCL	2	0.66	1.81	2.99	8.13	0.00	0.00
Eucalyptus	550	HCL	3	0.92	1.89	4.02	8.28	0.00	0.00
Eucalyptus	550	HCL	4	0.86	1.67	4.81	9.28	0.00	0.00
Delonix	350	None	1	0.84	0.63	6.36	4.77	0.00	0.00
Delonix	350	None	2	0.30	0.80	1.31	3.47	0.00	0.00
Delonix	350	None	3	0.41	0.75	1.85	3.43	0.00	0.00
Delonix	350	None	4	0.39	0.78	1.65	3.33	0.00	0.00
Delonix	550	None	1	0.93	1.80	2.30	4.43	0.00	0.00
Delonix	550	None	2	0.65	1.56	1.90	4.58	0.00	0.00
Delonix	550	None	3	0.73	1.64	1.95	4.34	0.00	0.00
Delonix	550	None	4	0.89	2.01	2.00	4.51	0.00	0.00
Delonix	350	Acetone	1	1.55	0.62	12.18	4.87	0.00	0.00
Delonix	350	Acetone	2	0.62	0.80	3.90	5.07	0.00	0.00
Delonix	350	Acetone	3	0.44	1.01	1.50	3.43	0.00	0.00
Delonix	350	Acetone	4	0.31	0.76	1.32	3.22	0.00	0.00
Delonix	550	Acetone	1	0.44	1.34	1.43	4.35	0.00	0.00
Delonix	550	Acetone	2	0.42	1.18	1.62	4.54	0.00	0.00
Delonix	550	Acetone	3	0.67	1.08	3.12	5.05	0.00	0.00
Delonix	550	Acetone	4	0.45	1.19	1.57	4.13	0.00	0.00
Delonix	350	H_2O	1	0.43	1.16	1.30	3.52	0.00	0.00
Delonix	350	H_2O	2	0.62	0.99	2.22	3.56	0.00	0.00
Delonix	350	H_2O	3	0.40	0.88	1.43	3.16	0.00	0.00
Delonix	350	H_2O	4	0.48	1.43	1.23	3.64	0.00	0.00
Delonix	550	H_2O	1	0.53	1.31	1.91	4.77	0.00	0.00
Delonix	550	H_2O	1	0.51	1.28	1.89	4.73	0.00	0.00
Delonix	550	H_2O	2	1.81	2.97	2.98	4.89	0.00	0.00
Delonix	550	H_2O	3	0.70	0.95	3.97	5.40	0.00	0.00
Delonix	550	H_2O	4						
Delonix	350	HCL	1	0.54	1.03	2.61	4.96	0.00	0.00
Delonix	350	HCL	2	0.68	1.01	3.56	5.30	0.00	0.00
Delonix	350	HCL	3	0.50	0.87	2.94	5.15	0.00	0.00

Delonix	350	HCL	4	0.53	0.96	2.88	5.27	0.00	0.00
Delonix	550	HCL	1	0.82	1.45	3.86	6.83	0.00	0.00
Delonix	550	HCL	2	0.45	1.26	2.32	6.53	0.00	0.00
Delonix	550	HCL	3						
Delonix	550	HCL	4	0.66	1.30	3.40	6.66	0.00	0.00
Delonix	350	None	1	0.46	0.90	2.41	4.73	0.00	0.00
Delonix	350	None	1	0.47	0.93	2.53	4.95	0.00	0.00
Delonix	350	None	2	0.47	1.01	3.30	7.02	0.00	0.00
Delonix	350	None	2	0.48	1.01	3.37	7.18	0.00	0.00
Delonix	350	None	3	0.36	0.94	1.68	4.38	0.00	0.00
Delonix	350	None	3	0.36	0.93	1.69	4.40	0.00	0.00
Delonix	350	None	4	0.25	0.82	1.51	4.98	0.00	0.00
Delonix	350	None	4	0.28	0.92	1.55	5.10	0.00	0.00
Delonix	550	None	1	1.04	1.49	5.41	7.78	0.00	0.00
Delonix	550	None	2	0.70	1.36	3.91	7.58	0.00	0.00
Delonix	550	None	3	0.90	1.67	3.64	6.74	0.00	
Delonix	550	None	4	0.85	1.37	5.17	8.33	0.00	0.00
Delonix	350	Acetone	1	0.47	1.06	2.30	5.21	0.00	0.00
Delonix	350	Acetone	2	0.66	1.29	2.62	5.11	0.00	0.00
Delonix	350	Acetone	3	0.66	1.07	3.35	5.42	0.00	0.00
Delonix	350	Acetone	4	0.49	0.87	2.71	4.79	0.00	0.00
Delonix	550	Acetone	1	0.81	1.54	4.58	8.71	0.00	0.00
Delonix	550	Acetone	2	1.66	1.74	8.74	9.18	0.00	0.00
Delonix	550	Acetone	3						
Delonix	550	Acetone	4	0.81	1.40	4.59	7.89	0.00	0.00
Delonix	350	H_2O	1	0.58	1.05	2.89	5.20	0.00	0.00
Delonix	350	H_2O	2	0.51	0.86	2.57	4.32	0.00	0.00
Delonix	350	H_2O	3						
Delonix	350	H_2O	4	0.56	0.92	2.68	4.45	0.00	0.00
Delonix	550	H_2O	1	0.80	1.40	3.75	6.56	0.00	0.00
Delonix	550	H_2O	2	0.73	1.35	4.32	7.95	0.00	0.00
Delonix	550	H_2O	3	1.03	1.60	5.34	8.28	0.00	0.00
Delonix	550	H_2O	4	0.65	1.14	4.74	8.35	0.00	0.00
Delonix	350	HCL	1	0.74	1.06	3.86	5.52	0.00	0.00
Delonix	350	HCL	2	0.73	1.26	3.68	6.37	0.00	0.00
Delonix	350	HCL	3	0.58	1.03	3.17	5.65	0.00	0.00
Delonix	350	HCL	4	0.59	1.10	3.85	7.20	0.00	0.00
Delonix	550	HCL	1						
Delonix	550	HCL	2	1.73	2.71	6.58	10.27	0.00	0.00
Delonix	550	HCL	3						
Delonix	550	HCL	4						

Tea	350	None	1	0.46	0.90	1.89	3.71	0.00	0.00
Tea	350	None	2	0.37	0.89	1.55	3.73	0.00	0.00
Tea	350	None	3	0.43	1.47	1.02	3.49	0.00	0.00
Tea	350	None	4	0.56	0.92	2.20	3.61	0.00	0.00
Tea	550	None	1	0.88	1.43	2.76	4.48	0.00	0.00
Tea	550	None	2	1.08	1.56	3.42	4.96	0.00	
Tea	550	None	3	0.82	1.55	2.32	4.41	0.00	0.00
Tea	550	None	4	0.52	1.43	1.68	4.63	0.00	0.00
Tea	350	Acetone	1	0.56	0.83	2.13	3.13	0.00	0.00
Tea	350	Acetone	2	0.52	0.86	1.90	3.16	0.00	0.00
Tea	350	Acetone	3	0.32	0.78	1.48	3.63	0.00	0.00
Tea	350	Acetone	4	0.35	0.96	1.18	3.20	0.00	0.00
Tea	550	Acetone	1	1.38	1.90	3.63	5.01	0.00	0.00
Tea	550	Acetone	2	0.69	1.40	2.35	4.76	0.00	0.00
Tea	550	Acetone	3	0.79	1.47	2.57	4.79	0.00	0.00
Tea	550	Acetone	4	0.90	1.95	2.43	5.27	0.00	0.00
Tea	350	H_2O	1	0.39	0.91	1.53	3.55	0.00	0.00
Tea	350	H_2O	2						
Tea	350	H_2O	3	1.15	0.96	4.71	3.91	0.00	0.00
Tea	350	H_2O	4	0.47	0.87	1.84	3.44	0.00	0.00
Tea	550	H_2O	1	0.79	1.39	2.76	4.89	0.00	0.00
Tea	550	H_2O	2	1.97	1.61	6.33	5.19	0.00	0.00
Tea	550	H_2O	3	0.50	1.32	1.72	4.51	0.00	0.00
Tea	550	H_2O	4	1.02	1.50	3.31	4.89	0.00	0.00
Tea	350	HCL	1	0.52	0.87	2.52	4.20	0.00	0.00
Tea	350	HCL	2	0.73	0.95	3.66	4.75	0.00	0.00
Tea	350	HCL	3	1.58	2.70	3.38	5.78	0.00	0.00
Tea	350	HCL	4	1.32	1.67	3.93	4.99	0.00	0.00
Tea	550	HCL	1	0.84	1.44	4.14	7.08	0.00	0.00
Tea	550	HCL	2	1.02	2.00	3.24	6.38	0.00	0.00
Tea	550	HCL	3	0.84	1.51	3.52	6.34	0.00	0.00
Tea	550	HCL	4	0.83	1.42	3.76	6.43	0.00	0.00
Tea	350	None	1	1.24	1.83	3.26	4.82	0.00	0.00
Tea	350	None	2	0.65	1.07	2.54	4.14	0.00	0.00
Tea	350	None	3	0.44	1.07	1.80	4.36	0.00	0.00
Tea	350	None	4						
Tea	550	None	1	0.78	1.66	3.12	6.61	0.00	0.00
Tea	550	None	2	0.83	1.95	3.18	7.43	0.00	0.00
Tea	550	None	3	2.29	2.95	7.61	9.82	0.00	0.00
Tea	550	None	4						
Tea	350	Acetone	1	0.73	1.20	3.38	5.54	0.00	0.00

Tea	350	Acetone	2	0.78	1.35	3.07	5.31	0.00	0.00
Tea	350	Acetone	3	0.60	0.98	3.03	4.93	0.00	0.00
Tea	350	Acetone	4	0.91	1.14	3.54	4.43	0.00	0.00
Tea	550	Acetone	1	1.47	1.79	7.28	8.88	0.00	0.00
Tea	550	Acetone	2	1.21	1.75	5.17	7.49	0.00	0.00
Tea	550	Acetone	3	1.10	1.48	4.86	6.56	0.00	0.00
Tea	550	Acetone	4	1.33	1.59	6.10	7.32	0.00	0.00
Tea	350	H_2O	1	0.39	1.04	1.50	4.06	0.00	0.00
Tea	350	H_2O	2	0.54	1.29	1.86	4.47	0.00	0.00
Tea	350	H_2O	3	0.78	1.09	3.65	5.11	0.00	0.00
Tea	350	H_2O	4	0.71	1.21	3.46	5.92	0.00	0.00
Tea	550	H_2O	1	0.70	1.29	4.14	7.66	0.00	0.00
Tea	550	H_2O	2	0.66	1.47	3.08	6.88	0.00	0.00
Tea	550	H_2O	3	0.84	1.69	3.24	6.48	0.00	0.00
Tea	550	H_2O	4	1.12	1.94	4.40	7.61	0.00	0.00
Tea	350	HCL	1	0.61	1.37	2.69	6.03	0.00	0.00
Tea	350	HCL	2	1.47	1.28	8.20	7.13	0.00	0.00
Tea	350	HCL	3	0.34	1.17	1.59	5.42	0.00	0.00
Tea	350	HCL	4	0.45	1.15	1.99	5.12	0.00	0.00
Tea	550	HCL	1	1.47	1.88	8.79	11.26	0.00	0.00
Tea	550	HCL	2	1.72	2.71	5.47	8.63	0.00	0.00
Tea	550	HCL	3						
Tea	550	HCL	4	1.57	1.86	6.69	7.89	0.00	0.00

Table 3.S10. Data from chapter 1 table 1.4.

Feedstock	Temp (°C)	Treatment	Rep	Pb (mg g^{-1})	Pb (mg $plant^{-1}$)	S (mg g^{-1})	S (mg $plant^{-1}$)	B (mg g^{-1})	B (mg $plant^{-1}$)
Rice	350	None	1	0.00	0.00	269.04	411.63	1.70	2.60
Rice	350	None	2	0.04	0.08	206.26	406.33	1.09	2.15
Rice	350	None	3	0.00	0.00	249.72	289.67	1.56	1.80
Rice	350	None	4	0.00	0.00	209.85	352.54	0.68	1.15
Rice	550	None	1	0.00	0.00	314.99	645.73	1.19	2.44
Rice	550	None	2	0.05	0.14	141.94	378.97	0.90	2.39
Rice	550	None	3	0.03	0.08	166.23	473.76	0.24	0.69
Rice	550	None	4	0.51	0.60	353.64	410.22	1.32	1.54
Rice	350	Acetone	1	0.03	0.06	147.96	306.28	0.01	0.02
Rice	350	Acetone	2	0.00	0.00	291.29	320.42	1.01	1.11
Rice	350	Acetone	3	0.00	0.00	134.89	364.20	0.28	0.76
Rice	350	Acetone	4	0.06	0.06	237.12	241.86	2.02	2.06
Rice	550	Acetone	1	0.00	0.00	263.74	664.62	1.29	3.25
Rice	550	Acetone	2	0.00	0.00	229.85	484.98	1.47	3.11
Rice	550	Acetone	3						

Rice	550	Acetone	4	0.03	0.08	191.57	450.20	0.54	1.26
Rice	350	H_2O	1	0.00	0.00	137.25	315.69	0.00	0.00
Rice	350	H_2O	2	0.00	0.00	157.39	371.44	0.67	1.58
Rice	350	H_2O	3	0.00	0.00	186.84	325.09	0.00	0.00
Rice	350	H_2O	4	0.00	0.00	123.44	320.95	0.04	0.09
Rice	550	H_2O	1	0.52	1.08	208.74	434.19	0.16	0.34
Rice	550	H_2O	2	0.41	0.82	267.68	540.71	1.21	2.45
Rice	550	H_2O	3	0.43	0.80	260.81	485.11	0.01	0.03
Rice	550	H_2O	4	0.35	1.01	142.28	412.60	0.00	0.00
Rice	350	HCL	1	0.82	1.40	240.10	408.16	0.00	0.00
Rice	350	HCL	2	0.34	0.95	105.15	293.36	0.27	0.76
Rice	350	HCL	3	1.19	1.92	215.89	347.59	0.00	0.00
Rice	350	HCL	4	1.57	4.21	142.24	381.20	0.00	0.00
Rice	550	HCL	1	0.75	1.36	254.93	463.97	1.05	1.91
Rice	550	HCL	1	0.87	1.58	269.15	489.86	1.99	3.63
Rice	550	HCL	2	1.56	3.12	250.18	500.36	1.28	2.57
Rice	550	HCL	3	0.26	0.52	273.86	544.98	0.00	0.00
Rice	550	HCL	4	0.29	0.73	165.44	420.22	0.00	0.00
Rice	350	None	1	0.06	0.14	153.18	350.78	0.86	1.98
Rice	350	None	2	0.00	0.00	150.10	363.25	0.00	0.00
Rice	350	None	3	0.00	0.00	128.38	304.25	0.00	0.00
Rice	350	None	4	0.04	0.12	114.98	312.75	0.00	0.00
Rice	550	None	1	0.06	0.14	223.23	529.07	0.00	0.00
Rice	550	None	2	0.26	0.35	417.18	559.02	0.00	0.00
Rice	550	None	3	0.09	0.22	217.46	504.50	0.00	0.00
Rice	550	None	4						
Rice	350	Acetone	1	0.04	0.07	246.51	419.07	0.00	0.00
Rice	350	Acetone	2	0.04	0.08	146.18	298.20	0.00	0.00
Rice	350	Acetone	3	0.06	0.10	244.44	437.55	0.00	0.00
Rice	350	Acetone	4	0.42	0.85	228.55	468.52	0.00	0.00
Rice	550	Acetone	1	0.39	0.40	595.95	619.79	0.00	0.00
Rice	550	Acetone	2	0.13	0.23	380.98	678.14	0.00	0.00
Rice	550	Acetone	3	0.18	0.39	225.52	500.66	0.00	0.00
Rice	550	Acetone	4	0.25	0.40	341.98	533.49	0.00	0.00
Rice	550	Acetone	4						
Rice	350	H_2O	1	0.00	0.00	882.68	1933.06	0.00	0.00
Rice	350	H_2O	2	0.05	0.11	145.89	334.09	0.00	0.00
Rice	350	H_2O	3	0.07	0.14	158.95	329.03	0.00	0.00
Rice	350	H_2O	4	0.05	0.13	112.30	281.87	0.00	0.00
Rice	550	H_2O	1	0.09	0.19	218.58	480.87	0.00	0.00

Rice	550	H_2O	2	0.57	1.41	169.93	421.42	0.00	0.00
Rice	550	H_2O	3	0.06	0.11	268.65	531.94	0.00	0.00
Rice	550	H_2O	4	0.06	0.10	318.31	502.93	0.00	0.00
Rice	350	HCL	1	0.18	0.43	135.64	329.60	0.00	0.00
Rice	350	HCL	2	0.16	0.47	-0.30	-0.90	108.07	323.12
Rice	350	HCL	3	0.10	0.26	-0.57	-1.40	115.48	284.09
Rice	350	HCL	4	0.00	0.00	-1.73	-1.30	365.03	273.77
Rice	550	HCL	1	0.25	0.35	0.05	0.07	345.44	483.62
Rice	550	HCL	2	0.38	0.43	-1.41	-1.58	351.14	393.27
Rice	550	HCL	3	0.11	0.28	-0.87	-2.22	157.86	404.12
Rice	550	HCL	4	0.10	0.27	-0.82	-2.19	156.29	420.42
Bagasse	350	None	1	0.07	0.10	-1.02	-1.62	192.46	304.09
Bagasse	350	None	2	0.00	0.00	-0.55	-1.21	106.41	233.05
Bagasse	350	None	3	0.00	0.00	-0.41	-1.03	95.44	237.64
Bagasse	350	None	4	0.00	0.00	-0.48	-1.08	106.18	238.90
Bagasse	550	None	1	0.00	0.00	-0.64	-1.17	189.94	345.68
Bagasse	550	None	2	0.00	0.00	-0.69	-1.16	190.39	319.86
Bagasse	550	None	3	0.00	0.00	-0.49	-1.27	114.80	300.77
Bagasse	550	None	4	0.00	0.00	-1.44	-1.06	500.55	370.40
Bagasse	350	Acetone	1	0.00	0.00	-0.35	-0.68	103.15	202.18
Bagasse	350	Acetone	2	0.00	0.00	-0.91	-1.00	207.41	228.15
Bagasse	350	Acetone	3	0.00	0.00	-0.57	-1.34	140.25	330.98
Bagasse	350	Acetone	4	0.02	0.06	-0.53	-1.19	116.97	263.19
Bagasse	550	Acetone	1	0.00	0.00	-0.58	-1.51	141.99	373.44
Bagasse	550	Acetone	2	0.00	0.00	-0.83	-1.96	169.33	399.62
Bagasse	550	Acetone	2	0.00	0.00	-0.76	-1.78	167.10	394.35
Bagasse	550	Acetone	3	0.08	0.11	-1.02	-1.44	265.81	374.79
Bagasse	550	Acetone	4	0.00	0.00	-0.68	-1.73	140.18	356.07
Bagasse	350	H_2O	1	0.00	0.00	-0.81	-1.47	146.29	264.78
Bagasse	350	H_2O	2	0.04	0.06	-0.99	-1.42	206.37	297.17
Bagasse	350	H_2O	3	0.00	0.00	-0.86	-1.37	149.46	239.13
Bagasse	350	H_2O	4	0.05	0.09	-0.81	-1.62	141.21	282.41
Bagasse	550	H_2O	1	0.00	0.00	-0.77	-0.91	284.94	336.23
Bagasse	550	H_2O	2	0.00	0.00	-1.03	-1.40	262.97	357.64
Bagasse	550	H_2O	3	0.00	0.00	-0.62	-1.86	118.28	354.85
Bagasse	550	H_2O	4	0.00	0.00	-0.79	-1.97	157.10	392.76
Bagasse	350	HCL	1	0.05	0.09	-0.70	-1.43	144.12	295.45
Bagasse	350	HCL	2	0.38	0.32	-1.90	-1.58	308.30	255.89
Bagasse	350	HCL	3	0.05	0.13	-0.61	-1.44	106.77	253.06
Bagasse	350	HCL	4	0.09	0.21	-0.63	-1.37	120.58	264.08

Bagasse	550	HCL	1	0.67	0.62	-2.31	-2.15	518.84	482.52
Bagasse	550	HCL	2	0.09	0.08	-1.86	-1.79	387.67	372.16
Bagasse	550	HCL	3	0.08	0.11	-1.25	-1.78	268.24	380.90
Bagasse	550	HCL	4	0.00	0.00	-1.08	-1.80	244.41	405.71
Bagasse	350	None	1	0.09	0.22	-0.73	-1.75	107.41	257.78
Bagasse	350	None	2	0.08	0.16	-0.80	-1.53	141.28	269.85
Bagasse	350	None	3	0.07	0.16	-0.75	-1.80	122.28	293.46
Bagasse	350	None	4	0.18	0.31	-1.03	-1.76	175.02	299.28
Bagasse	550	None	1	0.42	0.53	-1.87	-2.36	384.34	484.27
Bagasse	550	None	2	0.25	0.54	-1.39	-3.05	251.86	551.57
Bagasse	550	None	3	0.14	0.30	-1.12	-2.38	177.46	378.00
Bagasse	550	None	4	0.51	0.52	-2.19	-2.23	535.74	546.45
Bagasse	350	Acetone	1	0.07	0.12	-0.74	-1.34	157.74	285.51
Bagasse	350	Acetone	2	0.12	0.19	-0.78	-1.19	200.74	305.12
Bagasse	350	Acetone	3	0.06	0.16	-0.57	-1.44	107.51	269.85
Bagasse	350	Acetone	4	0.20	0.28	-1.48	-2.05	227.47	316.18
Bagasse	550	Acetone	1	0.26	0.44	-1.29	-2.19	271.79	462.04
Bagasse	550	Acetone	2	0.18	0.37	-1.13	-2.27	234.17	468.33
Bagasse	550	Acetone	3	0.92	0.79	-2.97	-2.55	686.56	590.44
Bagasse	550	Acetone	4	0.20	0.38	-0.96	-1.81	211.24	397.12
Bagasse	350	H_2O	1	0.14	0.32	-0.68	-1.56	97.84	225.03
Bagasse	350	H_2O	2	0.27	0.25	-1.87	-1.72	290.74	267.48
Bagasse	350	H_2O	3						
Bagasse	350	H_2O	4	0.00	0.00	498.45	418.70	0.00	0.00
Bagasse	550	H_2O	1	0.00	0.00	518.21	658.12	0.00	0.00
Bagasse	550	H_2O	2	0.00	0.00	225.59	480.50	0.00	0.00
Bagasse	550	H_2O	3	0.00	0.00	2842.53	852.76	0.00	0.00
Bagasse	550	H_2O	4	0.00	0.00	439.98	545.58	0.00	0.00
Bagasse	350	HCL	1	0.12	0.27	119.75	270.63	0.00	0.00
Bagasse	350	HCL	1						
Bagasse	350	HCL	2						
Bagasse	350	HCL	3	0.00	0.00	142.97	258.77	0.00	0.00
Bagasse	350	HCL	4	0.17	0.28	178.36	296.08	0.00	0.00
Bagasse	550	HCL	1	0.00	0.00	279.45	455.50	0.00	0.00
Bagasse	550	HCL	2	0.00	0.00	234.93	469.85	0.00	0.00
Bagasse	550	HCL	3	0.86	1.08	605.52	756.89	0.00	0.00
Bagasse	550	HCL	4	0.00	0.00	259.05	468.88	0.00	0.00
Maize stovers	350	None	1	0.00	0.00	192.65	252.37	0.00	0.00
Maize stovers	350	None	2	0.00	0.00	152.63	279.31	0.00	0.00
Maize stovers	350	None	3	0.00	0.00	127.97	246.99	0.00	0.00

Maize stovers	350	None	4	0.00	0.00	176.41	261.08	0.00	0.00
Maize stovers	550	None	1						
Maize stovers	550	None	2	0.00	0.00	534.04	432.57	0.00	0.00
Maize stovers	550	None	3	0.23	0.36	265.10	410.91	0.00	0.00
Maize stovers	550	None	4	0.00	0.00	591.21	579.39	0.00	0.00
Maize stovers	350	Acetone	1	0.00	0.00	149.99	265.48	0.00	0.00
Maize stovers	350	Acetone	2	0.00	0.00	137.43	305.08	0.00	0.00
Maize stovers	350	Acetone	3	0.00	0.00	144.20	320.13	0.00	0.00
Maize stovers	350	Acetone	4	0.00	0.00	150.96	298.90	0.00	0.00
Maize stovers	550	Acetone	1	0.00	0.00	228.25	372.05	0.00	0.00
Maize stovers	550	Acetone	2	0.00	0.00	189.11	376.33	0.00	0.00
Maize stovers	550	Acetone	3	0.00	0.00	718.07	574.46	0.00	0.00
Maize stovers	550	Acetone	4	0.57	1.77	128.54	401.04	0.00	0.00
Maize stovers	350	H_2O	1	0.00	0.00	124.79	260.81	0.00	0.00
Maize stovers	350	H_2O	2	0.00	0.00	171.61	253.99	0.00	0.00
Maize stovers	350	H_2O	3	0.00	0.00	134.00	254.59	0.00	0.00
Maize stovers	350	H_2O	4						
Maize stovers	550	H_2O	1	0.00	0.00	248.48	412.47	0.00	0.00
Maize stovers	550	H_2O	2	0.54	0.48	526.30	473.67	0.00	0.00
Maize stovers	550	H_2O	3	0.00	0.00	181.04	354.84	0.00	0.00
Maize stovers	550	H_2O	4	0.00	0.00	285.28	393.69	0.00	0.00
Maize stovers	350	HCL	1	0.00	0.00	206.29	272.31	0.00	0.00
Maize stovers	350	HCL	2	0.08	0.13	130.34	213.76	0.00	0.00
Maize stovers	350	HCL	3	0.00	0.00	169.97	299.15	0.00	0.00
Maize stovers	350	HCL	4	0.00	0.00	142.09	279.91	0.00	0.00
Maize stovers	550	HCL	1	0.00	0.00	178.91	377.50	0.00	0.00
Maize stovers	550	HCL	2	0.00	0.00	210.09	441.19	0.00	0.00
Maize stovers	550	HCL	3	0.00	0.00	243.29	413.59	0.00	0.00
Maize stovers	550	HCL	4	0.00	0.00	443.57	518.98	0.00	0.00
Maize stovers	350	None	1	0.00	0.00	165.81	295.14	0.00	0.00
Maize stovers	350	None	2	0.00	0.00	105.88	291.17	0.00	0.00
Maize stovers	350	None	3	0.00	0.00	96.74	249.58	0.00	0.00
Maize stovers	350	None	4	0.00	0.00	138.84	280.46	0.00	0.00
Maize stovers	550	None	1	0.00	0.00	451.39	546.18	0.00	0.00

Maize stovers	550	None	2	0.00	0.00	185.01	397.78	0.00	0.00
Maize stovers	550	None	3	0.00	0.00	359.50	629.13	0.00	0.00
Maize stovers	550	None	4	0.00	0.00	312.31	527.80	0.00	0.00
Maize stovers	350	Acetone	1	0.00	0.00	141.43	321.04	1.58	3.59
Maize stovers	350	Acetone	2	0.00	0.00	278.21	386.71	4.50	6.25
Maize stovers	350	Acetone	3	0.00	0.00	236.31	371.01	2.48	3.89
Maize stovers	350	Acetone	4	0.00	0.00	168.07	307.57	1.18	2.15
Maize stovers	550	Acetone	1	0.72	1.00	426.96	593.47	3.21	4.46
Maize stovers	550	Acetone	2	0.00	0.00	440.75	590.61	2.58	3.46
Maize stovers	550	Acetone	3	0.00	0.00	321.89	537.56	2.60	4.34
Maize stovers	550	Acetone	4	0.00	0.00	992.57	625.32	6.31	3.98
Maize stovers	350	H_2O	1	0.00	0.00	709.44	340.53	9.44	4.53
Maize stovers	350	H_2O	2	0.00	0.00	150.90	291.24	2.24	4.31
Maize stovers	350	H_2O	3	0.00	0.00	143.96	253.38	2.02	3.55
Maize stovers	350	H_2O	4	0.00	0.00	1663.89	332.78	13.73	2.75
Maize stovers	550	H_2O	1	0.00	0.00	268.22	498.89	1.60	2.97
Maize stovers	550	H_2O	2	0.00	0.00	370.23	584.96	2.45	3.87
Maize stovers	550	H_2O	3	0.00	0.00	476.08	533.21	4.20	4.70
Maize stovers	550	H_2O	4	0.00	0.00	170.75	447.35	2.10	5.51
Maize stovers	350	HCL	1	0.00	0.00	180.19	304.53	2.02	3.41
Maize stovers	350	HCL	2						
Maize stovers	350	HCL	3						
Maize stovers	350	HCL	4	0.00	0.00	193.15	305.18	2.18	3.44
Maize stovers	550	HCL	1	0.00	0.00	285.64	502.73	2.76	4.85
Maize stovers	550	HCL	2	0.00	0.00	394.91	477.84	4.68	5.67
Maize stovers	550	HCL	3	0.00	0.00	321.16	449.62	3.64	5.10
Maize stovers	550	HCL	4	0.00	0.00	432.35	523.15	4.49	5.43
Maize cobs	350	None	1	0.00	0.00	188.27	308.76	2.65	4.34
Maize cobs	350	None	2	0.00	0.00	106.31	279.59	1.77	4.66
Maize cobs	350	None	3	0.00	0.00	174.26	277.07	2.03	3.22
Maize cobs	350	None	4	0.00	0.00	623.47	467.60	7.42	5.57
Maize cobs	550	None	1	0.00	0.00	309.91	449.37	2.46	3.57
Maize cobs	550	None	2	0.00	0.00	310.07	499.21	3.01	4.85
Maize cobs	550	None	3	0.00	0.00	249.01	420.83	2.40	4.06
Maize cobs	550	None	4	0.00	0.00	245.36	385.21	2.91	4.57
Maize cobs	350	Acetone	1	0.00	0.00	149.74	314.45	1.47	3.09

Maize cobs	350	Acetone	2	0.00	0.00	200.42	268.57	1.93	2.59
Maize cobs	350	Acetone	3	0.00	0.00	163.87	294.97	1.89	3.40
Maize cobs	350	Acetone	4	0.00	0.00	130.43	305.21	1.82	4.27
Maize cobs	550	Acetone	1	0.00	0.00	165.37	416.72	1.64	4.13
Maize cobs	550	Acetone	2						
Maize cobs	550	Acetone	3	0.00	0.00	215.25	441.27	3.43	7.03
Maize cobs	550	Acetone	4	0.00	0.00	185.01	434.77	2.87	6.74
Maize cobs	350	H_2O	1	0.00	0.00	145.73	292.91	2.35	4.72
Maize cobs	350	H_2O	2	0.00	0.00	190.43	297.07	4.42	6.89
Maize cobs	350	H_2O	3	0.00	0.00	172.86	302.51	3.15	5.52
Maize cobs	350	H_2O	4						
Maize cobs	550	H_2O	1	0.00	0.00	306.68	401.75	2.86	3.75
Maize cobs	550	H_2O	2	0.00	0.00	230.92	378.71	2.53	4.15
Maize cobs	550	H_2O	3	0.00	0.00	438.44	539.28	4.18	5.14
Maize cobs	550	H_2O	4	0.00	0.00	193.61	484.02	2.36	5.90
Maize cobs	350	HCL	1	0.00	0.00	134.19	280.46	1.90	3.96
Maize cobs	350	HCL	2	0.00	0.00	157.69	288.57	2.86	5.24
Maize cobs	350	HCL	3	0.00	0.00	162.74	283.17	2.99	5.21
Maize cobs	350	HCL	4	0.00	0.00	193.71	294.45	1.52	2.30
Maize cobs	550	HCL	1	0.00	0.00	344.00	436.88	3.03	3.85
Maize cobs	550	HCL	2	0.00	0.00	318.18	496.36	3.47	5.41
Maize cobs	550	HCL	3	0.00	0.00	275.74	479.78	2.57	4.47
Maize cobs	550	HCL	4	0.00	0.00	420.63	487.93	4.22	4.90
Maize cobs	350	None	1						
Maize cobs	350	None	2	0.00	0.00	173.14	327.23	2.19	4.14
Maize cobs	350	None	3	0.00	0.00	188.26	329.46	2.23	3.91
Maize cobs	350	None	4	0.00	0.00	133.26	293.17	2.46	5.41
Maize cobs	550	None	1	0.00	0.00	243.17	513.09	3.00	6.33
Maize cobs	550	None	2	0.00	0.00	211.62	522.71	1.91	4.73
Maize cobs	550	None	3	0.00	0.00	318.75	618.38	3.03	5.87
Maize cobs	550	None	4	0.00	0.00	256.19	438.08	1.70	2.90
Maize cobs	350	Acetone	1	0.00	0.00	112.15	278.12	1.32	3.26
Maize cobs	350	Acetone	2	0.00	0.00	677.30	277.69	8.59	3.52
Maize cobs	350	Acetone	3	0.00	0.00	250.76	315.96	2.69	3.39
Maize cobs	350	Acetone	4	0.00	0.00	199.90	351.83	1.91	3.36
Maize cobs	550	Acetone	1	0.00	0.00	565.51	622.06	2.94	3.23
Maize cobs	550	Acetone	2	0.00	0.00	290.84	575.86	2.35	4.66
Maize cobs	550	Acetone	3	0.00	0.00	317.81	626.09	2.24	4.41
Maize cobs	550	Acetone	4	0.00	0.00	282.47	531.04	1.06	2.00
Maize cobs	350	H_2O	1	0.00	0.00	157.28	259.51	1.76	2.90

Maize cobs	350	H_2O	2	0.00	0.00	166.79	306.90	2.43	4.48
Maize cobs	350	H_2O	3	0.00	0.00	162.23	382.85	1.30	3.06
Maize cobs	350	H_2O	4	0.00	0.00	124.70	295.55	1.83	4.33
Maize cobs	550	H_2O	1	0.00	0.00	685.99	541.93	5.77	4.56
Maize cobs	550	H_2O	2	0.00	0.00	259.02	569.85	1.28	2.82
Maize cobs	550	H_2O	3	0.00	0.00	165.20	510.48	1.20	3.71
Maize cobs	550	H_2O	4	0.00	0.00	316.03	508.81	3.06	4.92
Maize cobs	350	HCL	1	0.00	0.00	178.57	348.21	0.74	1.44
Maize cobs	350	HCL	2	0.00	0.00	133.48	312.34	1.29	3.02
Maize cobs	350	HCL	3						
Maize cobs	350	HCL	4	0.00	0.00	173.32	384.77	1.88	4.17
Maize cobs	550	HCL	1	0.00	0.00	492.50	472.80	5.74	5.51
Maize cobs	550	HCL	2	0.00	0.00	292.84	459.76	2.75	4.32
Maize cobs	550	HCL	3	0.00	0.00	332.57	458.95	2.42	3.34
Maize cobs	550	HCL	4	0.00	0.00	347.74	618.98	3.16	5.62
Eucalyptus	350	None	1	0.00	0.00	156.26	264.08	1.49	2.52
Eucalyptus	350	None	2	0.00	0.00	115.38	311.52	0.95	2.56
Eucalyptus	350	None	3	0.00	0.00	144.97	318.93	0.73	1.60
Eucalyptus	350	None	4	0.00	0.00	169.08	302.65	1.54	2.76
Eucalyptus	550	None	1	0.00	0.00	195.40	384.94	1.85	3.64
Eucalyptus	550	None	2	0.00	0.00	242.57	385.68	2.07	3.29
Eucalyptus	550	None	3	0.00	0.00	228.61	427.50	1.51	2.83
Eucalyptus	550	None	4	0.00	0.00	174.08	436.95	1.33	3.34
Eucalyptus	350	Acetone	1	0.00	0.00	169.67	295.23	1.13	1.96
Eucalyptus	350	Acetone	2	0.57	1.50	113.79	301.54	0.75	1.98
Eucalyptus	350	Acetone	3	0.00	0.00	199.61	347.33	1.03	1.79
Eucalyptus	350	Acetone	4	0.00	0.00	108.73	287.04	0.71	1.87
Eucalyptus	550	Acetone	1	0.00	0.00	935.82	870.32	3.95	3.67
Eucalyptus	550	Acetone	2	0.00	0.00	639.06	619.89	5.14	4.98
Eucalyptus	550	Acetone	3	0.00	0.00	297.77	509.20	2.73	4.67
Eucalyptus	550	Acetone	4	0.00	0.00	626.72	501.37	5.75	4.60
Eucalyptus	350	H_2O	1	0.00	0.00	177.88	225.91	2.53	3.21
Eucalyptus	350	H_2O	1	0.00	0.00	172.33	218.87	2.28	2.89
Eucalyptus	350	H_2O	2	0.00	0.00	138.18	257.02	1.56	2.90
Eucalyptus	350	H_2O	3	0.00	0.00	92.53	269.26	1.10	3.21
Eucalyptus	350	H_2O	4	0.00	0.00	147.53	267.03	1.05	1.90
Eucalyptus	550	H_2O	1	0.00	0.00	342.66	418.04	3.36	4.09
Eucalyptus	550	H_2O	2	0.00	0.00	831.68	706.93	8.59	7.30
Eucalyptus	550	H_2O	3	0.00	0.00	1345.91	619.12	15.62	7.18
Eucalyptus	550	H_2O	4	0.00	0.00	221.34	398.41	1.67	3.01

Eucalyptus	350	HCL	1	0.00	0.00	174.14	337.84	2.03	3.94
Eucalyptus	350	HCL	2	0.00	0.00	155.10	260.58	0.99	1.66
Eucalyptus	350	HCL	3	0.00	0.00	162.44	308.63	1.08	2.04
Eucalyptus	350	HCL	4	0.00	0.00	150.32	285.62	0.71	1.34
Eucalyptus	550	HCL	1	0.00	0.00	318.45	420.35	2.17	2.87
Eucalyptus	550	HCL	2	0.00	0.00	166.39	344.43	1.90	3.93
Eucalyptus	550	HCL	3	0.00	0.00	374.51	460.65	2.78	3.42
Eucalyptus	550	HCL	4	0.00	0.00	210.59	379.06	1.96	3.52
Eucalyptus	350	None	1	0.00	0.00	137.66	283.58	1.32	2.71
Eucalyptus	350	None	2	0.00	0.00	223.94	541.94	1.51	3.66
Eucalyptus	350	None	3	0.00	0.00	105.38	244.47	0.93	2.17
Eucalyptus	350	None	4	0.00	0.00	209.77	302.08	1.90	2.74
Eucalyptus	550	None	1						
Eucalyptus	550	None	2	0.00	0.00	266.38	506.13	2.29	4.36
Eucalyptus	550	None	3	0.00	0.00	459.89	648.44	2.22	3.13
Eucalyptus	550	None	4	0.00	0.00	515.74	644.67	3.64	4.54
Eucalyptus	350	Acetone	1	0.00	0.00	261.16	428.31	2.82	4.62
Eucalyptus	350	Acetone	2	0.00	0.00	182.29	304.42	1.71	2.86
Eucalyptus	350	Acetone	3	0.00	0.00	136.35	325.88	1.21	2.89
Eucalyptus	350	Acetone	4	0.00	0.00	191.63	344.93	1.84	3.32
Eucalyptus	550	Acetone	1	0.00	0.00	143.05	406.25	0.87	2.48
Eucalyptus	550	Acetone	2	0.00	0.00	366.09	402.70	4.48	4.92
Eucalyptus	550	Acetone	3	0.00	0.00	310.37	881.44	0.96	2.73
Eucalyptus	550	Acetone	4	0.00	0.00	418.68	460.55	4.21	4.63
Eucalyptus	350	H_2O	1	0.00	0.00	121.79	306.91	1.17	2.95
Eucalyptus	350	H_2O	2	0.00	0.00	93.71	229.58	0.12	0.28
Eucalyptus	350	H_2O	3	0.00	0.00	432.12	937.71	455.40	988.22
Eucalyptus	350	H_2O	4	0.00	0.00	97.10	196.14	1.09	2.21
Eucalyptus	550	H_2O	1	0.00	0.00	89.18	200.64	1.66	3.74
Eucalyptus	550	H_2O	2	0.00	0.00	124.66	219.40	2.28	4.01
Eucalyptus	550	H_2O	3	0.00	0.00	211.59	372.39	1.03	1.81
Eucalyptus	550	H_2O	4	0.00	0.00	256.09	486.58	1.69	3.21
Eucalyptus	350	HCL	1	0.00	0.00	182.90	288.97	1.66	2.62
Eucalyptus	350	HCL	2	0.00	0.00	110.46	275.04	0.33	0.82
Eucalyptus	350	HCL	3	0.00	0.00	126.50	328.89	1.00	2.60
Eucalyptus	350	HCL	4	0.00	0.00	134.66	277.41	0.83	1.71
Eucalyptus	550	HCL	1	0.00	0.00	165.29	398.34	0.80	1.93
Eucalyptus	550	HCL	2	0.00	0.00	148.94	405.11	2.61	7.11
Eucalyptus	550	HCL	3	0.00	0.00	188.43	388.16	1.99	4.09
Eucalyptus	550	HCL	4	0.00	0.00	198.49	383.08	1.61	3.11
Delonix	350	None	1	0.00	0.00	484.69	363.52	10.59	7.94

Delonix	350	None	2	0.00	0.00	116.74	308.19	1.22	3.21
Delonix	350	None	3	0.00	0.00	134.73	250.59	1.23	2.29
Delonix	350	None	4	0.00	0.00	148.44	299.85	0.94	1.90
Delonix	550	None	1	0.00	0.00	231.18	446.18	0.96	1.85
Delonix	550	None	2	0.48	1.15	183.21	441.53	1.53	3.69
Delonix	550	None	3	0.00	0.00	203.57	453.97	1.84	4.09
Delonix	550	None	4	0.00	0.00	217.62	489.65	0.92	2.07
Delonix	350	Acetone	1	0.00	0.00	856.62	342.65	8.60	3.44
Delonix	350	Acetone	2	0.00	0.00	280.98	365.28	1.49	1.94
Delonix	350	Acetone	3	0.00	0.00	127.28	291.46	0.86	1.97
Delonix	350	Acetone	4	0.00	0.00	114.56	279.53	1.04	2.55
Delonix	550	Acetone	1	0.00	0.00	135.14	412.17	1.14	3.47
Delonix	550	Acetone	2	0.00	0.00	150.38	421.07	1.31	3.66
Delonix	550	Acetone	3	0.00	0.00	268.02	434.20	1.88	3.05
Delonix	550	Acetone	4	0.00	0.00	149.01	390.40	1.27	3.34
Delonix	350	H_2O	1	0.00	0.00	117.50	317.25	0.81	2.19
Delonix	350	H_2O	2	0.00	0.00	181.22	289.95	0.92	1.48
Delonix	350	H_2O	3	0.00	0.00	128.81	283.39	0.88	1.93
Delonix	350	H_2O	4	0.00	0.00	103.23	304.54	0.76	2.23
Delonix	550	H_2O	1	0.00	0.00	165.87	414.67	0.85	2.11
Delonix	550	H_2O	1	0.00	0.00	163.73	409.31	1.16	2.91
Delonix	550	H_2O	2	0.00	0.00	261.46	428.79	1.48	2.43
Delonix	550	H_2O	3	0.00	0.00	289.44	393.63	0.91	1.24
Delonix	550	H_2O	4						
Delonix	350	HCL	1	0.00	0.00	147.19	279.65	1.09	2.07
Delonix	350	HCL	2	0.00	0.00	196.22	292.37	1.83	2.73
Delonix	350	HCL	3	0.00	0.00	162.44	284.27	1.34	2.35
Delonix	350	HCL	4	0.00	0.00	176.48	322.95	0.97	1.78
Delonix	550	HCL	1	0.00	0.00	241.40	427.28	2.10	3.72
Delonix	550	HCL	2	0.00	0.00	141.99	398.98	1.04	2.92
Delonix	550	HCL	3						
Delonix	550	HCL	4	0.00	0.00	210.25	412.08	1.32	2.58
Delonix	350	None	1	0.00	0.00	147.75	289.59	1.19	2.34
Delonix	350	None	1	0.00	0.00	160.68	314.93	0.77	1.50
Delonix	350	None	2	0.00	0.00	160.26	341.35	0.93	1.99
Delonix	350	None	2	0.00	0.00	159.27	339.25	1.75	3.74
Delonix	350	None	3	0.00	0.00	92.24	239.83	1.07	2.79
Delonix	350	None	3	0.00	0.00	95.05	247.14	0.68	1.76
Delonix	350	None	4	0.00	0.00	90.38	297.34	0.54	1.77
Delonix	350	None	4	0.00	0.00	87.14	286.70	0.47	1.54
Delonix	550	None	1	0.00	0.00	392.86	565.71	2.27	3.27

Delonix	550	None	2	0.00	0.00	360.47	699.31	0.93	1.80
Delonix	550	None	3	0.00		238.00	440.29	1.59	2.94
Delonix	550	None	4	0.00	0.00	444.17	715.11	1.65	2.65
Delonix	350	Acetone	1	0.00	0.00	148.39	336.84	1.19	2.69
Delonix	350	Acetone	2	0.00	0.00	172.13	335.65	1.12	2.18
Delonix	350	Acetone	3	0.00	0.00	236.33	382.85	0.75	1.21
Delonix	350	Acetone	4	0.00	0.00	180.36	319.24	0.64	1.13
Delonix	550	Acetone	1	0.00	0.00	334.89	636.30	2.26	4.29
Delonix	550	Acetone	2	0.00	0.00	750.18	787.69	2.53	2.65
Delonix	550	Acetone	3						
Delonix	550	Acetone	4	0.00	0.00	407.89	701.57	1.45	2.49
Delonix	350	H_2O	1	0.00	0.00	140.08	252.14	1.46	2.63
Delonix	350	H_2O	2	0.00	0.00	176.89	297.18	1.61	2.70
Delonix	350	H_2O	3						
Delonix	350	H_2O	4	0.00	0.00	167.92	278.75	1.42	2.35
Delonix	550	H_2O	1	0.00	0.00	308.09	539.15	1.68	2.93
Delonix	550	H_2O	2	0.00	0.00	351.38	646.54	1.30	2.38
Delonix	550	H_2O	3	0.00	0.00	319.98	495.96	1.27	1.96
Delonix	550	H_2O	4	0.00	0.00	304.24	535.46	2.10	3.70
Delonix	350	HCL	1	0.00	0.00	204.51	292.45	1.73	2.47
Delonix	350	HCL	2	0.38	0.65	194.48	336.45	1.61	2.79
Delonix	350	HCL	3	0.00	0.00	151.65	269.93	1.28	2.28
Delonix	350	HCL	4	0.00	0.00	172.36	322.32	1.60	2.99
Delonix	550	HCL	1						
Delonix	550	HCL	2	0.63	0.98	314.97	491.36	2.47	3.85
Delonix	550	HCL	3						
Delonix	550	HCL	4						
Tea	350	None	1	0.00	0.00	159.07	311.78	1.70	3.32
Tea	350	None	2	0.00	0.00	119.09	287.01	0.77	1.86
Tea	350	None	3	0.00	0.00	95.02	325.91	0.73	2.49
Tea	350	None	4	0.00	0.00	195.80	321.12	1.32	2.17
Tea	550	None	1	0.00	0.00	259.07	419.70	2.08	3.37
Tea	550	None	2	0.00		315.09	456.89	1.70	2.47
Tea	550	None	3	0.00	0.00	241.92	459.64	1.17	2.22
Tea	550	None	4	0.00	0.00	146.70	403.43	1.33	3.65
Tea	350	Acetone	1	0.00	0.00	202.04	297.00	1.37	2.01
Tea	350	Acetone	2	0.00	0.00	166.35	276.13	1.47	2.44
Tea	350	Acetone	3	0.00	0.00	127.07	312.58	0.88	2.15
Tea	350	Acetone	4	0.00	0.00	109.44	296.59	0.77	2.08
Tea	550	Acetone	1	0.54	0.74	292.65	403.85	1.91	2.63
Tea	550	Acetone	2	0.00	0.00	227.07	460.95	1.92	3.90

Tea	550	Acetone	3	0.00	0.00	236.55	439.98	1.13	2.10
Tea	550	Acetone	4	0.00	0.00	186.69	405.12	1.86	4.03
Tea	350	H_2O	1	0.00	0.00	149.74	347.40	1.32	3.06
Tea	350	H_2O	2						
Tea	350	H_2O	3	0.00	0.00	416.33	345.55	2.82	2.34
Tea	350	H_2O	4	0.00	0.00	153.26	286.59	1.01	1.89
Tea	550	H_2O	1	0.00	0.00	240.12	425.02	1.40	2.48
Tea	550	H_2O	2	0.00	0.00	528.16	433.09	3.89	3.19
Tea	550	H_2O	3	0.00	0.00	157.01	411.38	1.02	2.66
Tea	550	H_2O	4	0.00	0.00	287.02	424.79	1.51	2.23
Tea	350	HCL	1	0.00	0.00	150.54	251.40	1.15	1.92
Tea	350	HCL	2	0.00	0.00	225.66	293.36	1.05	1.37
Tea	350	HCL	3	0.00	0.00	206.83	353.68	1.21	2.06
Tea	350	HCL	4	0.00	0.00	247.98	314.94	0.00	0.00
Tea	550	HCL	1	0.00	0.00	212.88	364.02	0.00	0.00
Tea	550	HCL	2	0.00	0.00	189.80	373.90	0.00	0.00
Tea	550	HCL	3	0.00	0.00	194.12	349.41	0.00	0.00
Tea	550	HCL	4	0.00	0.00	218.39	373.45	0.00	0.00
Tea	350	None	1	0.00	0.00	216.87	320.96	0.00	0.00
Tea	350	None	2	0.00	0.00	150.47	245.26	0.00	0.00
Tea	350	None	3	0.00	0.00	125.57	303.89	0.00	0.00
Tea	350	None	4						
Tea	550	None	1	0.00	0.00	215.73	457.35	0.00	0.00
Tea	550	None	2	0.00	0.00	260.89	610.48	0.00	0.00
Tea	550	None	3	0.26	0.33	482.18	622.01	0.00	0.00
Tea	550	None	4						
Tea	350	Acetone	1	0.00	0.00	251.73	412.83	0.00	0.00
Tea	350	Acetone	2	0.00	0.00	215.38	372.61	0.00	0.00
Tea	350	Acetone	3	0.00	0.00	180.34	293.95	0.00	0.00
Tea	350	Acetone	4	0.00	0.00	249.00	311.25	0.00	0.00
Tea	550	Acetone	1	0.00	0.00	683.67	834.08	0.00	0.00
Tea	550	Acetone	2	0.00	0.00	493.74	715.93	0.00	0.00
Tea	550	Acetone	3	0.15	0.21	542.24	732.02	0.00	0.00
Tea	550	Acetone	4	0.00	0.00	525.55	630.67	0.00	0.00
Tea	350	H_2O	1	0.00	0.00	102.78	277.50	0.00	0.00
Tea	350	H_2O	2	0.09	0.23	118.82	285.16	0.00	0.00
Tea	350	H_2O	3	0.00	0.00	225.08	315.11	0.00	0.00
Tea	350	H_2O	4	0.00	0.00	183.55	313.88	0.00	0.00
Tea	550	H_2O	1	0.00	0.00	231.50	428.28	0.00	0.00
Tea	550	H_2O	2	0.00	0.00	236.94	528.37	0.00	0.00

Tea	550	H_2O	3	0.00	0.00	292.59	585.17	0.00	0.00
Tea	550	H_2O	4	0.00	0.00	250.75	433.80	0.00	0.00
Tea	350	HCL	1	0.00	0.00	110.86	248.32	0.00	0.00
Tea	350	HCL	2	0.00	0.00	393.30	342.17	0.00	0.00
Tea	350	HCL	3	0.00	0.00	93.83	319.01	0.00	0.00
Tea	350	HCL	4	0.00	0.00	112.13	289.29	0.00	0.00
Tea	550	HCL	1	0.00	0.00	400.71	512.91	0.00	0.00
Tea	550	HCL	2	0.00	0.00	308.32	487.14	0.00	0.00
Tea	550	HCL	3						
Tea	550	HCL	4	0.00	0.00	345.58	407.79	0.00	0.00

Table S3.11. Data from chapter 1 table 1.6.

Feedstock	Treat	Rep	Shoot biomass (g)	Total N (mg plant^{-1})	Ndfa (% of total N)	Ndfa (mg N g^{-1})	Ndfa (mg N plant^{-1})
Delonix	Fert-High	1	1.22	32.61	10.03	2.68	3.27
Delonix	Fert-High	2	2.20	73.43	36.47	12.17	26.78
Delonix	Fert-High	3	1.43	50.91	22.55	8.03	11.48
Delonix	Fert-High	4	1.61	44.34	14.27	3.93	6.33
Delonix	Fert-High	5	2.28	63.37	23.09	6.42	14.63
Delonix	Fert-Low	1	1.77	53.78	11.40	3.46	6.13
Delonix	Fert-Low	2	1.63	46.44	3.85	1.10	1.79
Delonix	Fert-Low	3	1.41	31.90	12.94	2.93	4.13
Delonix	Fert-Low	4	2.14	65.60	7.12	2.18	4.67
Delonix	Fert-Low	5	2.25	65.25	2.24	0.65	1.46
Delonix	Fert-Low ph Low	1	1.80	53.67	7.75	2.31	4.16
Delonix	Fert-Low ph Low	2	1.51	48.66	9.36	3.02	4.55
Delonix	Fert-Low ph Low	3	2.23	65.24	5.90	1.73	3.85
Delonix	Fert-Low ph Low	4	1.02	25.02	8.86	2.17	2.22
Delonix	Fert-Low ph Low	5	1.78	53.30	13.00	3.89	6.93
Eucalyptus	Fert-High	1	2.16	58.97	6.54	1.78	3.86
Eucalyptus	Fert-High	2	1.85	58.96	10.19	3.25	6.01
Eucalyptus	Fert-High	3	1.82	61.42	8.61	2.91	5.29
Eucalyptus	Fert-High	4	2.10	60.36	11.53	3.31	6.96
Eucalyptus	Fert-High	5	2.16	65.37	0.43	0.13	0.28
Eucalyptus	Fert-Low	1	1.80	54.20	10.14	3.05	5.50
Eucalyptus	Fert-Low	2	1.93	58.62	4.20	1.28	2.46

Eucalyptus	Fert-Low	3	1.94	74.34	-0.46	-0.18	-0.34
Eucalyptus	Fert-Low	4	1.85	58.10	1.16	0.37	0.68
Eucalyptus	Fert-Low	5	1.78	49.37	4.96	1.38	2.45
Eucalyptus	Fert-Low ph Low	1	0.79	32.48	2.49	1.02	0.81
Eucalyptus	Fert-Low ph Low	2					
Eucalyptus	Fert-Low ph Low	3	1.30	49.30	6.04	2.29	2.98
Eucalyptus	Fert-Low ph Low	4	1.42	45.26	0.37	0.12	0.17
Eucalyptus	Fert-Low ph Low	5	2.23	63.97	8.18	2.35	5.24
Control	Fert-High	1	2.80	84.01	-1.27	-0.38	-1.07
Control	Fert-High	2	2.86	87.07	-1.52	-0.46	-1.32
Control	Fert-High	3	3.00	87.77	2.04	0.60	1.79
Control	Fert-High	4	2.29	66.39	-6.34	-1.84	-4.21
Control	Fert-High	5	2.76	72.19	-2.28	-0.60	-1.64
Control	Fert-Low	1	1.95	75.56	-0.27	-0.10	-0.20
Control	Fert-Low	2	1.52	35.83	2.48	0.59	0.89
Control	Fert-Low	3	1.25	51.98	5.19	2.16	2.70
Control	Fert-Low	4	2.23	51.63	4.97	1.15	2.57
Control	Fert-Low	5	2.17	74.23	2.05	0.70	1.52
Control	No-Fert	1	1.71	59.12	3.34	1.15	1.97
Control	No-Fert	2	1.38	44.24	-3.49	-1.12	-1.54
Control	No-Fert	3	1.94	64.51	3.77	1.25	2.43
Control	No-Fert	4	1.51	50.19	1.32	0.44	0.66
Control	No-Fert	5	2.07	74.26	0.71	0.26	0.53

Table 3.S12. Data from chapter 1 table 1.6.

Feedstock	Treat	Root No.	Score	No. of obs.	Individual root fragment score (%)	Total slide score (%)
Delonix	Fert-High	a	27.00	38.00	71.05	67.52
Delonix	Fert-High	b	10.00	38.00	26.32	
Delonix	Fert-High	c	35.00	41.00	85.37	
Delonix	Fert-High	d	34.00	40.00	85.00	
Delonix	Fert-High	a	53.00	60.00	88.33	81.47
Delonix	Fert-High	b	29.00	45.00	64.44	
Delonix	Fert-High	c	50.00	67.00	74.63	
Delonix	Fert-High	d	57.00	60.00	95.00	
Delonix	Fert-High	a	60.00	60.00	100.00	96.41
Delonix	Fert-High	b	48.00	55.00	87.27	
Delonix	Fert-High	c	40.00	40.00	100.00	
Delonix	Fert-High	d	40.00	40.00	100.00	

Delonix	Fert-High	a	60.00	60.00	100.00	94.05
Delonix	Fert-High	b	45.00	45.00	100.00	
Delonix	Fert-High	c	38.00	48.00	79.17	
Delonix	Fert-High	d	31.00	32.00	96.88	
Delonix	Fert-High	a	54.00	60.00	90.00	94.86
Delonix	Fert-High	b	26.00	27.00	96.30	
Delonix	Fert-High	c	26.00	28.00	92.86	
Delonix	Fert-High	d	60.00	60.00	100.00	
Delonix	Fert-Low	a	40.00	45.00	88.89	93.14
Delonix	Fert-Low	b	20.00	21.00	95.24	
Delonix	Fert-Low	c	19.00	20.00	95.00	
Delonix	Fert-Low	d	16.00	16.00	100.00	
Delonix	Fert-Low	a	15.00	18.00	83.33	86.81
Delonix	Fert-Low	b	29.00	29.00	100.00	
Delonix	Fert-Low	c	14.00	18.00	77.78	
Delonix	Fert-Low	d	21.00	26.00	80.77	
Delonix	Fert-Low	a	18.00	27.00	66.67	83.91
Delonix	Fert-Low	b	13.00	17.00	76.47	
Delonix	Fert-Low	c	21.00	21.00	100.00	
Delonix	Fert-Low	d	21.00	22.00	95.45	
Delonix	Fert-Low	a	29.00	29.00	100.00	95.60
Delonix	Fert-Low	b	19.00	20.00	95.00	
Delonix	Fert-Low	c	20.00	20.00	100.00	
Delonix	Fert-Low	d	19.00	22.00	86.36	
Delonix	Fert-Low	a	29.00	29.00	100.00	100.00
Delonix	Fert-Low	b	28.00	28.00	100.00	
Delonix	Fert-Low	c	27.00	27.00	100.00	
Delonix	Fert-Low	d	30.00	30.00	100.00	
Delonix	Fert-Low ph Low	a	23.00	23.00	100.00	89.19
Delonix	Fert-Low ph Low	b	27.00	27.00	100.00	
Delonix	Fert-Low ph Low	c	26.00	36.00	72.22	
Delonix	Fert-Low ph Low	d	23.00	25.00	92.00	
Delonix	Fert-Low ph Low	a	7.00	31.00	22.58	65.49
Delonix	Fert-Low ph Low	b	27.00	29.00	93.10	
Delonix	Fert-Low ph Low	c	22.00	25.00	88.00	
Delonix	Fert-Low ph Low	d	18.00	28.00	64.29	
Delonix	Fert-Low ph Low	a	26.00	26.00	100.00	73.64
Delonix	Fert-Low ph Low	b	19.00	31.00	61.29	
Delonix	Fert-Low ph Low	c	15.00	27.00	55.56	

Delonix	Fert-Low ph Low	d	21.00	26.00	80.77	
Delonix	Fert-Low ph Low	a	29.00	29.00	100.00	73.39
Delonix	Fert-Low ph Low	b	6.00	24.00	25.00	
Delonix	Fert-Low ph Low	c	19.00	25.00	76.00	
Delonix	Fert-Low ph Low	d	26.00	31.00	83.87	
Delonix	Fert-Low ph Low	a	33.00	33.00	100.00	90.08
Delonix	Fert-Low ph Low	b	27.00	29.00	93.10	
Delonix	Fert-Low ph Low	c	20.00	30.00	66.67	
Delonix	Fert-Low ph Low	d	29.00	29.00	100.00	
Eucalyptus	Fert-High	a	29.00	29.00	100.00	88.24
Eucalyptus	Fert-High	b	25.00	33.00	75.76	
Eucalyptus	Fert-High	c	21.00	25.00	84.00	
Eucalyptus	Fert-High	d	30.00	32.00	93.75	
Eucalyptus	Fert-High	a	36.00	36.00	100.00	98.48
Eucalyptus	Fert-High	b	30.00	32.00	93.75	
Eucalyptus	Fert-High	c	35.00	35.00	100.00	
Eucalyptus	Fert-High	d	29.00	29.00	100.00	
Eucalyptus	Fert-High	a	42.00	43.00	97.67	96.03
Eucalyptus	Fert-High	b	41.00	42.00	97.62	
Eucalyptus	Fert-High	c	36.00	36.00	100.00	
Eucalyptus	Fert-High	d	26.00	30.00	86.67	
Eucalyptus	Fert-High	a	27.00	27.00	100.00	72.18
Eucalyptus	Fert-High	b	27.00	43.00	62.79	
Eucalyptus	Fert-High	c	13.00	34.00	38.24	
Eucalyptus	Fert-High	d	29.00	29.00	100.00	
Eucalyptus	Fert-High	a	26.00	28.00	92.86	94.64
Eucalyptus	Fert-High	b	30.00	30.00	100.00	
Eucalyptus	Fert-High	c	28.00	28.00	100.00	
Eucalyptus	Fert-High	d	22.00	26.00	84.62	
Eucalyptus	Fert-Low	a	19.00	28.00	67.86	78.91
Eucalyptus	Fert-Low	b	18.00	34.00	52.94	
Eucalyptus	Fert-Low	c	36.00	36.00	100.00	
Eucalyptus	Fert-Low	d	28.00	30.00	93.33	
Eucalyptus	Fert-Low	a	30.00	34.00	88.24	69.72
Eucalyptus	Fert-Low	b	11.00	16.00	68.75	
Eucalyptus	Fert-Low	c	7.00	31.00	22.58	
Eucalyptus	Fert-Low	d	28.00	28.00	100.00	
Eucalyptus	Fert-Low	a	7.00	27.00	25.93	37.04
Eucalyptus	Fert-Low	b	5.00	31.00	16.13	
Eucalyptus	Fert-Low	c	3.00	24.00	12.50	

Eucalyptus	Fert-Low	d	25.00	26.00	96.15	
Eucalyptus	Fert-Low	a	27.00	38.00	71.05	72.50
Eucalyptus	Fert-Low	b	26.00	27.00	96.30	
Eucalyptus	Fert-Low	c	18.00	28.00	64.29	
Eucalyptus	Fert-Low	d	16.00	27.00	59.26	
Eucalyptus	Fert-Low	a	17.00	31.00	54.84	50.86
Eucalyptus	Fert-Low	b	7.00	27.00	25.93	
Eucalyptus	Fert-Low	c	9.00	30.00	30.00	
Eucalyptus	Fert-Low	d	26.00	28.00	92.86	
Eucalyptus	Fert-Low ph Low	a	6.00	27.00	22.22	25.58
Eucalyptus	Fert-Low ph Low	b	12.00	29.00	41.38	
Eucalyptus	Fert-Low ph Low	c	11.00	34.00	32.35	
Eucalyptus	Fert-Low ph Low	d	4.00	39.00	10.26	
Eucalyptus	Fert-Low ph Low	a				
Eucalyptus	Fert-Low ph Low	b				
Eucalyptus	Fert-Low ph Low	c				
Eucalyptus	Fert-Low ph Low	d				
Eucalyptus	Fert-Low ph Low	a	28.00	37.00	75.68	82.64
Eucalyptus	Fert-Low ph Low	b	35.00	37.00	94.59	
Eucalyptus	Fert-Low ph Low	c	28.00	35.00	80.00	
Eucalyptus	Fert-Low ph Low	d	28.00	35.00	80.00	
Eucalyptus	Fert-Low ph Low	a	31.00	31.00	100.00	86.79
Eucalyptus	Fert-Low ph Low	b	22.00	27.00	81.48	
Eucalyptus	Fert-Low ph Low	c	14.00	23.00	60.87	
Eucalyptus	Fert-Low ph Low	d	25.00	25.00	100.00	
Eucalyptus	Fert-Low ph Low	a	28.00	39.00	71.79	60.99
Eucalyptus	Fert-Low ph Low	b	6.00	35.00	17.14	
Eucalyptus	Fert-Low ph Low	c	18.00	32.00	56.25	
Eucalyptus	Fert-Low ph Low	d	34.00	35.00	97.14	
Control	Fert-High	a	17.00	38.00	44.74	43.13
Control	Fert-High	b	35.00	39.00	89.74	
Control	Fert-High	c	11.00	43.00	25.58	
Control	Fert-High	d	6.00	40.00	15.00	
Control	Fert-High	a	21.00	41.00	51.22	51.63
Control	Fert-High	b	13.00	45.00	28.89	
Control	Fert-High	c	34.00	34.00	100.00	
Control	Fert-High	d	11.00	33.00	33.33	

Control	Fert-High	a	31.00	31.00	100.00	52.14
Control	Fert-High	b	12.00	43.00	27.91	
Control	Fert-High	c	3.00	35.00	8.57	
Control	Fert-High	d	27.00	31.00	87.10	
Control	Fert-High	a	0.00	35.00	0.00	44.03
Control	Fert-High	b	17.00	36.00	47.22	
Control	Fert-High	c	19.00	33.00	57.58	
Control	Fert-High	d	23.00	30.00	76.67	
Control	Fert-High	a	25.00	36.00	69.44	71.54
Control	Fert-High	b	27.00	34.00	79.41	
Control	Fert-High	c	16.00	29.00	55.17	
Control	Fert-High	d	25.00	31.00	80.65	
Control	Fert-Low	a	28.00	29.00	96.55	66.94
Control	Fert-Low	b	17.00	31.00	54.84	
Control	Fert-Low	c	13.00	32.00	40.63	
Control	Fert-Low	d	25.00	32.00	78.13	
Control	Fert-Low	a	2.00	32.00	6.25	33.08
Control	Fert-Low	b	7.00	32.00	21.88	
Control	Fert-Low	c	32.00	38.00	84.21	
Control	Fert-Low	d	3.00	31.00	9.68	
Control	Fert-Low	a	2.00	30.00	6.67	13.79
Control	Fert-Low	b	5.00	29.00	17.24	
Control	Fert-Low	c	8.00	31.00	25.81	
Control	Fert-Low	d	1.00	26.00	3.85	
Control	Fert-Low	a	8.00	29.00	27.59	48.39
Control	Fert-Low	b	9.00	34.00	26.47	
Control	Fert-Low	c	23.00	28.00	82.14	
Control	Fert-Low	d	20.00	33.00	60.61	
Control	Fert-Low	a	25.00	25.00	100.00	49.54
Control	Fert-Low	b	18.00	34.00	52.94	
Control	Fert-Low	c	3.00	25.00	12.00	
Control	Fert-Low	d	8.00	25.00	32.00	
Control	No-Fert	a	26.00	26.00	100.00	97.12
Control	No-Fert	b	26.00	28.00	92.86	
Control	No-Fert	c	26.00	26.00	100.00	
Control	No-Fert	d	23.00	24.00	95.83	
Control	No-Fert	a	23.00	27.00	85.19	68.52
Control	No-Fert	b	16.00	33.00	48.48	
Control	No-Fert	c	10.00	23.00	43.48	
Control	No-Fert	d	25.00	25.00	100.00	
Control	No-Fert	a	0.00	25.00	0.00	40.52
Control	No-Fert	b	25.00	29.00	86.21	

Control	No-Fert	c	1.00	27.00	3.70	
Control	No-Fert	d	21.00	35.00	60.00	
Control	No-Fert	a	1.00	34.00	2.94	18.10
Control	No-Fert	b	4.00	29.00	13.79	
Control	No-Fert	c	16.00	27.00	59.26	
Control	No-Fert	d	0.00	26.00	0.00	
Control	No-Fert	a	2.00	33.00	6.06	17.50
Control	No-Fert	b	14.00	28.00	50.00	
Control	No-Fert	c	5.00	28.00	17.86	
Control	No-Fert	d	0.00	31.00	0.00	

Table 3.S13. Data from chapter 2 tables S2.2, S2.3, and S2.4 and figures 2.1, 2.2, and 2.3.

Inoculant	Treat	Rep	Soil (%)	Sand (%)	Shoot dry weight (g)	Root dry weight (g)	Number of nodules	Nodule dry weight (g)
Control	WD4	1	100	0	0.25	0.05	0	0
Control	WD4	2	100	0	0.61	0.12	0	0
Control	WD4	3	100	0	0.6	0.11	0	0
Control	WD4	4	100	0	0.48	0.12	0	0
Control	WD4	5	100	0	0.36	0.09	0	0
Control	WD4	1	75	25	0.49	0.15	0	0
Control	WD4	2	75	25	0.55	0.14	0	0
Control	WD4	3	75	25	0.55	0.1	0	0
Control	WD4	4	75	25	0.33	0.13	0	0
Control	WD4	5	75	25	0.73	0.15	0	0
Control	WD4	1	50	50	0.87	0.28	0	0
Control	WD4	2	50	50	0.68	0.14	0	0
Control	WD4	3	50	50	0.48	0.13	0	0
Control	WD4	4	50	50	0.61	0.19	0	0
Control	WD4	5	50	50	0.52	0.08	0	0
Control	WD4	1	25	75	0.24	0.07	0	0
Control	WD4	2	25	75	0.37	0.09	0	0
Control	WD4	3	25	75	0.41	0.03	0	0
Control	WD4	4	25	75	0.27	0.05	0	0
Control	WD4	5	25	75				
Control	WD4	1	0	100	0.11	0.04	0	0
Control	WD4	2	0	100	0.15	0.09	0	0
Control	WD4	3	0	100				

Control	WD4	4	0	100	0.15	0.06	0	0
Control	WD4	5	0	100	0.16	0.07	0	0
Control	WD1	1	100	0	0.7	0.08	0	0
Control	WD1	2	100	0	0.46			
Control	WD1	3	100	0	0.8	0.2	0	0
Control	WD1	4	100	0	0.6	0.06		
Control	WD1	5	100	0	0.42	0.04	0	0
Control	WD1	1	75	25	0.35	0.03	0	0
Control	WD1	2	75	25	0.78	0.12	0	0
Control	WD1	3	75	25				
Control	WD1	4	75	25	0.84	0.11	0	0
Control	WD1	5	75	25	0.74	0.09	0	0
Control	WD1	1	50	50	0.87	0.21	0	0
Control	WD1	2	50	50	0.43	0.09	0	0
Control	WD1	3	50	50	0.91	0.17	0	0
Control	WD1	4	50	50	0.54	0.12	0	0
Control	WD1	5	50	50	0.5	0.08	0	0
Control	WD1	1	25	75	0.5	0.08	0	0
Control	WD1	2	25	75	0.32	0.03		
Control	WD1	3	25	75	0.19	0.02	0	0
Control	WD1	4	25	75	0.28	0.02	0	0
Control	WD1	5	25	75	0.36	0.06	0	0
Control	WD1	1	0	100	0.08	0	0	0
Control	WD1	2	0	100	0.06	0	0	0
Control	WD1	3	0	100				
Control	WD1	4	0	100	0.14			
Control	WD1	5	0	100	0.03	0	0	0
Control	WP	1	100	0	0.95	0.19	0	0
Control	WP	2	100	0	0.86	0.11	0	0
Control	WP	3	100	0	0.73	0.15	0	0
Control	WP	4	100	0				
Control	WP	5	100	0	0.54	0.08	0	0
Control	WP	1	75	25	0.74	0.2	0	0
Control	WP	2	75	25	1	0.12	0	0
Control	WP	3	75	25	0.6	0.17	0	0
Control	WP	4	75	25	0.42	0.07	0	0
Control	WP	5	75	25	0.92	0.16	0	0
Control	WP	1	50	50	0.29	0	0	0
Control	WP	2	50	50	0.72	0.37	0	0
Control	WP	3	50	50	0.83	0.33	0	0
Control	WP	4	50	50	0.83	0.27	0	0
Control	WP	5	50	50	1.22	0.38	21	6.51

Control	WP	1	25	75	0.32	0.04	0	0
Control	WP	2	25	75	0.23	0.07	0	0
Control	WP	3	25	75	0.45	0.1	0	0
Control	WP	4	25	75	0.34	0.14	32	0.64
Control	WP	5	25	75	0.31	0.6	0	0
Control	WP	1	0	100	0.2	0.03	0	0
Control	WP	2	0	100	0.13	0.06	0	0
Control	WP	3	0	100	0.2	0.03	5	0.8
Control	WP	4	0	100	0.28	0.05	0	0
Control	WP	5	0	100	0.21	0.02	0	0
Biochar	WD4	1	100	0	1.2	0.17	0	0
Biochar	WD4	2	100	0	1.37	0.25	0	0
Biochar	WD4	3	100	0	0.92	0.15	0	0
Biochar	WD4	4	100	0	1.39	0.32	32	1.51
Biochar	WD4	5	100	0	1.02	0.16	0	0
Biochar	WD4	1	75	25	0.63	0.1	0	0
Biochar	WD4	2	75	25	0.67	0.07	0	0
Biochar	WD4	3	75	25	1.09	0.2	36	3.87
Biochar	WD4	4	75	25	0.47	0.13	0	0
Biochar	WD4	5	75	25	1.1	0.2	0	0
Biochar	WD4	1	50	50	0.97	0.13	11	1.3
Biochar	WD4	2	50	50	0.63	0.15	20	0.9
Biochar	WD4	3	50	50	1	0.15	6	0.77
Biochar	WD4	4	50	50	0.65	0.12	0	0
Biochar	WD4	5	50	50	0.86	0.18	0	0
Biochar	WD4	1	25	75	0.55	0.06	12	0.35
Biochar	WD4	2	25	75	0.28	0.02	0	
Biochar	WD4	3	25	75	0.42	0.08	0	
Biochar	WD4	4	25	75	0.13	0	0	
Biochar	WD4	5	25	75	0.32	0.08	0	
Biochar	WD4	1	0	100	0.21	0.02	0	
Biochar	WD4	2	0	100	0.03	0.01	0	
Biochar	WD4	3	0	100	0.09	0	0	
Biochar	WD4	4	0	100	0.14	0.04	0	
Biochar	WD4	5	0	100	0.15	0.06	0	
Biochar	WD1	1	100	0	0.34	0.02	0	
Biochar	WD1	2	100	0	1.2	0.28	0	
Biochar	WD1	3	100	0	0.79	0.11	0	
Biochar	WD1	4	100	0	0.96	0.15		
Biochar	WD1	5	100	0	0.66	0.17	0	
Biochar	WD1	1	75	25	0.64	0.09	0	
Biochar	WD1	2	75	25	0.87	0.17	0	

Biochar	WD1	3	75	25	1.11	0.27	0	
Biochar	WD1	4	75	25				
Biochar	WD1	5	75	25	0.37	0.08	0	
Biochar	WD1	1	50	50	0.38	0.06	0	
Biochar	WD1	2	50	50	0.26	0.01	0	
Biochar	WD1	3	50	50	0.36	0.04	0	
Biochar	WD1	4	50	50	0.52	0.1	0	
Biochar	WD1	5	50	50	0.42	0.11	0	
Biochar	WD1	1	25	75	0.29	0	0	
Biochar	WD1	2	25	75	0.38	0.01	0	
Biochar	WD1	3	25	75	0.35	0.05	0	
Biochar	WD1	4	25	75	0.38	0.01	0	
Biochar	WD1	5	25	75	0.2	0.03	0	
Biochar	WD1	1	0	100	0.17	0.05	0	
Biochar	WD1	2	0	100	0.11	0.03	0	
Biochar	WD1	3	0	100	0.14	0	0	
Biochar	WD1	4	0	100	0.1	0.02	0	
Biochar	WD1	5	0	100				
Biochar	WP	1	100	0	0.81	0.2	0	
Biochar	WP	2	100	0	0.44	0.14	0	
Biochar	WP	3	100	0	0.45	0.05	0	
Biochar	WP	4	100	0	0.62	0.17	0	
Biochar	WP	5	100	0	0.6	0.12	0	
Biochar	WP	1	75	25	0.6	0.17	0	
Biochar	WP	2	75	25	0.34	0.11	0	
Biochar	WP	3	75	25	0.21	0.03	7	0.32
Biochar	WP	4	75	25	0.49	0.16	0	
Biochar	WP	5	75	25	0.51	0.23	0	
Biochar	WP	1	50	50	0.51	0.08	0	
Biochar	WP	2	50	50	0.75	0.16	0	
Biochar	WP	3	50	50	0.34	0.09	0	
Biochar	WP	4	50	50	0.39	0.11	0	
Biochar	WP	5	50	50	0.71	0.15	0	
Biochar	WP	1	25	75	0.34	0.04	0	
Biochar	WP	2	25	75	0.29	0.04	7	0.26
Biochar	WP	3	25	75	0.19	0.03	0	
Biochar	WP	4	25	75	0.34	0.07	0	
Biochar	WP	5	25	75	0.32	0	0	
Biochar	WP	1	0	100	0.33	0.05	18	2.59
Biochar	WP	2	0	100	0.35	0.04	32	7.48
Biochar	WP	3	0	100	0.43	0.12	17	3.11
Biochar	WP	4	0	100	0.29	0.08	43	6.81

Biochar	WP	5	0	100	0.5	0.08	30	4.43
Bagasse	WD4	1	100	0	0.52	0.08	56	24.06
Bagasse	WD4	2	100	0	0.62	0.09	55	23.55
Bagasse	WD4	3	100	0	0.44	0.07	10	8.33
Bagasse	WD4	4	100	0	0.51	0.06	46	25.07
Bagasse	WD4	5	100	0	0.44	0.09	127	19.44
Bagasse	WD4	1	75	25	0.37	0.04	32	11.4
Bagasse	WD4	2	75	25	0.45	0.04	22	11.95
Bagasse	WD4	3	75	25	0.49	0.02	29	14.07
Bagasse	WD4	4	75	25	0.42	0.08	43	22.89
Bagasse	WD4	5	75	25	0.48	0.07	49	28.58
Bagasse	WD4	1	50	50	0.73	0.08	48	27.23
Bagasse	WD4	2	50	50	0.69	0.11	38	19.22
Bagasse	WD4	3	50	50	0.64	0.11	158	44.37
Bagasse	WD4	4	50	50	0.33	0.03	28	17.44
Bagasse	WD4	5	50	50	0.28	0.05	28	15.37
Bagasse	WD4	1	25	75	0.45	0.08	32	13.54
Bagasse	WD4	2	25	75	0.54	0.11	48	20.44
Bagasse	WD4	3	25	75	0.36	0.04	49	8.75
Bagasse	WD4	4	25	75	0.34	0.09	91	21.77
Bagasse	WD4	5	25	75	0.21	0.02	8	1.54
Bagasse	WD4	1	0	100	0.04	0	0	
Bagasse	WD4	2	0	100				
Bagasse	WD4	3	0	100	0.75	0.03	0	
Bagasse	WD4	4	0	100	0.22	0.07	37	10.74
Bagasse	WD4	5	0	100	0.29	0.09	5	3.13
Bagasse	WD1	1	100	0	0.52	0.07	44	23.54
Bagasse	WD1	2	100	0	0.39	0.07	54	21.21
Bagasse	WD1	3	100	0	0.32	0.18	61	40.08
Bagasse	WD1	4	100	0	0.35	0.07	26	6.41
Bagasse	WD1	5	100	0	0.72	0.13	81	36.93
Bagasse	WD1	1	75	25	0.79	0.13	37	39.86
Bagasse	WD1	2	75	25	0.76	0.08	64	49.5
Bagasse	WD1	3	75	25	1.13	0.15	148	68.66
Bagasse	WD1	4	75	25	0.62	0.09	78	41.85
Bagasse	WD1	5	75	25	0.99	0.1	69	52.99
Bagasse	WD1	1	50	50	0.33	0.08	22	9.62
Bagasse	WD1	2	50	50	0.32	0.1	11	6.75
Bagasse	WD1	3	50	50	0.33	0.08	8	5.56
Bagasse	WD1	4	50	50	0.32	0.05	32	10.61
Bagasse	WD1	5	50	50	0.55	0.12	27	16.1
Bagasse	WD1	1	25	75	0.41	0.06	26	18.33

Bagasse	WD1	2	25	75	0.19	0.05	26	4.99
Bagasse	WD1	3	25	75	0.26	0.06	14	6.1
Bagasse	WD1	4	25	75	0.26	0.04	47	5.26
Bagasse	WD1	5	25	75	0.13	0.02	12	1.02
Bagasse	WD1	1	0	100	0.06	0.04	0	
Bagasse	WD1	2	0	100	0.15	0.04	0	
Bagasse	WD1	3	0	100	0.15	0.02	0	
Bagasse	WD1	4	0	100	0.08	0.02	0	
Bagasse	WD1	5	0	100	0.11	0.04	0	
Bagasse	WP	1	100	0	0.65	0.06	9	4.13
Bagasse	WP	2	100	0	0.63	0.11	85	13.54
Bagasse	WP	3	100	0	0.7	0.07	36	8.02
Bagasse	WP	4	100	0	0.33	0.03	50	9.05
Bagasse	WP	5	100	0	0.44	0.02	32	15.45
Bagasse	WP	1	75	25	0.2	0	13	0.34
Bagasse	WP	2	75	25	0.6	0.14	42	20.4
Bagasse	WP	3	75	25	0.48	0.05	31	8.14
Bagasse	WP	4	75	25	0.45	0.1	12	4.62
Bagasse	WP	5	75	25	0.45	0.11	18	7.58
Bagasse	WP	1	50	50	0.63	0.08	30	10.79
Bagasse	WP	2	50	50	0.35	0.09	19	1.43
Bagasse	WP	3	50	50	0.48	0.13	39	4.53
Bagasse	WP	4	50	50				
Bagasse	WP	5	50	50	0.44	0.1	9	2.52
Bagasse	WP	1	25	75	0.17	0.02	13	2.05
Bagasse	WP	2	25	75	0.43	0.07	28	4.07
Bagasse	WP	3	25	75	0.31	0.08	104	19.72
Bagasse	WP	4	25	75	0.39	0.06	18	2.09
Bagasse	WP	5	25	75	0.73	0.08	75	7.85
Bagasse	WP	1	0	100	0.17	0.01	19	2.17
Bagasse	WP	2	0	100	0.14	0.04	43	6.18
Bagasse	WP	3	0	100	0.2	0.03	12	1.51
Bagasse	WP	4	0	100	0.12	0.3	4	0.56
Bagasse	WP	5	0	100	0.2	0.04	6	0.56

Table 3.S14. Data from chapter 2 tables 2.4 and 2.5.

Sample ID	Nodule no.	Inoculant	Treat	Rep	Soil (%)	Sand (%)	Nodule occupancy
S82	4	Biochar	WD4	2	75	25	Not 899
S82	12	Biochar	WD4	2	75	25	Not 899
S82	26	Biochar	WD4	2	75	25	Not 899

S82	31	Biochar	WD4	2	75	25	Not 899	
S82	33	Biochar	WD4	2	75	25	Not 899	
S83	3	Biochar	WD4	3	75	25		889
S83	5	Biochar	WD4	3	75	25		889
S83	14	Biochar	WD4	3	75	25		889
S83	15	Biochar	WD4	3	75	25		889
S84	1	Biochar	WD4	4	75	25	Not 899	
S84	8	Biochar	WD4	4	75	25	Not 899	
S84	19	Biochar	WD4	4	75	25	Not 899	
S84	31	Biochar	WD4	4	75	25	Not 899	
S84	43	Biochar	WD4	4	75	25	Not 899	
S84	54	Biochar	WD4	4	75	25	Not 899	
S84	56	Biochar	WD4	4	75	25	Not 899	
S85	4	Biochar	WD4	5	75	25	Not 899	
S85	11	Biochar	WD4	5	75	25	Not 899	
S85	23	Biochar	WD4	5	75	25	Not 899	
S88	56	Biochar	WD4	3	50	50	Not 899	
S89	2	Biochar	WD4	4	50	50	Not 899	
S89	3	Biochar	WD4	4	50	50	Not 899	
S89	6	Biochar	WD4	4	50	50	Not 899	
S89	7	Biochar	WD4	4	50	50	Not 899	
S89	20	Biochar	WD4	4	50	50	Not 899	
S89	27	Biochar	WD4	4	50	50	Not 899	
S89	49	Biochar	WD4	4	50	50	Not 899	
S89	54	Biochar	WD4	4	50	50	Not 899	
S89	70	Biochar	WD4	4	50	50	Not 899	
S90	2	Biochar	WD4	5	50	50	Not 899	
S90	4	Biochar	WD4	5	50	50	Not 899	
S90	10	Biochar	WD4	5	50	50	Not 899	
S90	43	Biochar	WD4	5	50	50	Not 899	
S90	59	Biochar	WD4	5	50	50	Not 899	
S90	62	Biochar	WD4	5	50	50	Not 899	
S92	3	Biochar	WD4	2	25	75	Not 899	
S92	4	Biochar	WD4	2	25	75	Not 899	
S92	5	Biochar	WD4	2	25	75	Not 899	
S92	6	Biochar	WD4	2	25	75	Not 899	
S92	13	Biochar	WD4	2	25	75	Not 899	
S92	17	Biochar	WD4	2	25	75	Not 899	
S92	19	Biochar	WD4	2	25	75	Not 899	
S92	22	Biochar	WD4	2	25	75	Not 899	
S92	23	Biochar	WD4	2	25	75		899
S92	24	Biochar	WD4	2	25	75	Not 899	

S92	29	Biochar	WD4	2	25	75	Not 899	
S92	33	Biochar	WD4	2	25	75	Not 899	
S92	36	Biochar	WD4	2	25	75	Not 899	
S92	43	Biochar	WD4	2	25	75	Not 899	
S92	45	Biochar	WD4	2	25	75	Not 899	
S92	48	Biochar	WD4	2	25	75	Not 899	
S92	51	Biochar	WD4	2	25	75	Not 899	
S92	52	Biochar	WD4	2	25	75	Not 899	
S92	54	Biochar	WD4	2	25	75	Not 899	
S92	60	Biochar	WD4	2	25	75	Not 899	
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S163	39	Bagasse	WD4	3	50	50	Not 899	
S163	42	Bagasse	WD4	3	50	50		899
S163	46	Bagasse	WD4	3	50	50	Not 899	

S163	47	Bagasse	WD4	3	50	50	Not 899	
S164	9	Bagasse	WD4	4	50	50	Not 899	
S164	19	Bagasse	WD4	4	50	50	Not 899	
S164	20	Bagasse	WD4	4	50	50	Not 899	
S164	25	Bagasse	WD4	4	50	50	Not 899	
S165	5	Bagasse	WD4	5	50	50	Not 899	
S165	17	Bagasse	WD4	5	50	50	Not 899	
S165	20	Bagasse	WD4	5	50	50	Not 899	
S165	23	Bagasse	WD4	5	50	50	Not 899	
S166	3	Bagasse	WD4	1	25	75		899
S166	6	Bagasse	WD4	1	25	75	Not 899	
S166	10	Bagasse	WD4	1	25	75	No DNA	
S166	20	Bagasse	WD4	1	25	75	Not 899	
S166	21	Bagasse	WD4	1	25	75	Not 899	
S166	23	Bagasse	WD4	1	25	75	Not 899	
S166	24	Bagasse	WD4	1	25	75	Not 899	
S166	26	Bagasse	WD4	1	25	75		899
S166	30	Bagasse	WD4	1	25	75	Not 899	
S167	3	Bagasse	WD4	2	25	75	Not 899	
S167	10	Bagasse	WD4	2	25	75	Not 899	
S167	11	Bagasse	WD4	2	25	75	Not 899	
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S167	14	Bagasse	WD4	2	25	75		899
S167	21	Bagasse	WD4	2	25	75	Not 899	
S167	22	Bagasse	WD4	2	25	75	Not 899	
S167	23	Bagasse	WD4	2	25	75	Not 899	
S167	28	Bagasse	WD4	2	25	75	Not 899	
S167	30	Bagasse	WD4	2	25	75	No DNA	
S167	31	Bagasse	WD4	2	25	75	Not 899	
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S168	2	Bagasse	WD4	3	25	75	Not 899	
S168	4	Bagasse	WD4	3	25	75	Not 899	
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S168	8	Bagasse	WD4	3	25	75		899
S168	9	Bagasse	WD4	3	25	75	Not 899	
S168	15	Bagasse	WD4	3	25	75	Not 899	
S168	17	Bagasse	WD4	3	25	75	Not 899	
S168	20	Bagasse	WD4	3	25	75	Not 899	
S168	24	Bagasse	WD4	3	25	75	Not 899	
S168	26	Bagasse	WD4	3	25	75	Not 899	
S168	28	Bagasse	WD4	3	25	75	Not 899	

S168	30	Bagasse	WD4	3	25	75	Not 899
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S169	1	Bagasse	WD4	4	25	75	Not 899
S169	2	Bagasse	WD4	4	25	75	Not 899
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S169	17	Bagasse	WD4	4	25	75	Not 899
S169	18	Bagasse	WD4	4	25	75	899
S169	19	Bagasse	WD4	4	25	75	No DNA
S169	20	Bagasse	WD4	4	25	75	No DNA
S169	21	Bagasse	WD4	4	25	75	Not 899
S169	22	Bagasse	WD4	4	25	75	Not 899
S169	24	Bagasse	WD4	4	25	75	No DNA
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S169	26	Bagasse	WD4	4	25	75	Not 899
S169	27	Bagasse	WD4	4	25	75	Not 899
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S169	35	Bagasse	WD4	4	25	75	Not 899
S169	36	Bagasse	WD4	4	25	75	Not 899
S169	37	Bagasse	WD4	4	25	75	Not 899
S169	38	Bagasse	WD4	4	25	75	Not 899
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S169	41	Bagasse	WD4	4	25	75	Not 899
S169	42	Bagasse	WD4	4	25	75	Not 899
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S169	44	Bagasse	WD4	4	25	75	Not 899
S169	45	Bagasse	WD4	4	25	75	Not 899
S169	46	Bagasse	WD4	4	25	75	Not 899
S169	47	Bagasse	WD4	4	25	75	Not 899
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S169	50	Bagasse	WD4	4	25	75	Not 899
S169	52	Bagasse	WD4	4	25	75	Not 899
S169	53	Bagasse	WD4	4	25	75	No DNA
S169	54	Bagasse	WD4	4	25	75	No DNA
S169	55	Bagasse	WD4	4	25	75	Not 899
S169	56	Bagasse	WD4	4	25	75	Not 899
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S170	5	Bagasse	WD4	5	25	75	Not 899
S170	6	Bagasse	WD4	5	25	75	Not 899
S174		Bagasse	WD4	0	100	29	Not 899
S174		Bagasse	WD4	0	100	20	Not 899
S174		Bagasse	WD4	0	100	16	Not 899
S174		Bagasse	WD4	0	100	10	Not 899
S176	13	Bagasse	WD1	1	100	0	Not 899
S176	21	Bagasse	WD1	1	100	0	Not 899
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S202	2	Bagasse	WP	2	100	0	Not 899
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S202	15	Bagasse	WP	2	100	0	Not 899
S202	17	Bagasse	WP	2	100	0	899
S202	18	Bagasse	WP	2	100	0	Not 899

S202	19	Bagasse	WP	2	100	0	899
S202	21	Bagasse	WP	2	100	0	899
S202	22	Bagasse	WP	2	100	0	899
S202	23	Bagasse	WP	2	100	0	899
S202	24	Bagasse	WP	2	100	0	899
S202	27	Bagasse	WP	2	100	0	899
S202	28	Bagasse	WP	2	100	0	899
S202	29	Bagasse	WP	2	100	0	No DNA
S202	32	Bagasse	WP	2	100	0	899
S202	34	Bagasse	WP	2	100	0	899
S202	35	Bagasse	WP	2	100	0	899
S202	36	Bagasse	WP	2	100	0	899
S202	37	Bagasse	WP	2	100	0	899
S202	38	Bagasse	WP	2	100	0	No DNA
S202	39	Bagasse	WP	2	100	0	899
S202	40	Bagasse	WP	2	100	0	899
S202	41	Bagasse	WP	2	100	0	899
S202	42	Bagasse	WP	2	100	0	899
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S202	46	Bagasse	WP	2	100	0	899
S202	47	Bagasse	WP	2	100	0	899
S202	48	Bagasse	WP	2	100	0	899
S203	9	Bagasse	WP	3	100	0	Not 899
S203	18	Bagasse	WP	3	100	0	No DNA
S203	27	Bagasse	WP	3	100	0	Not 899
S203	29	Bagasse	WP	3	100	0	No DNA
S203	30	Bagasse	WP	3	100	0	No DNA
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S204	18	Bagasse	WP	4	100	0	Not 899
S204	19	Bagasse	WP	4	100	0	Not 899
S204	20	Bagasse	WP	4	100	0	Not 899
S204	23	Bagasse	WP	4	100	0	Not 899
S204	25	Bagasse	WP	4	100	0	Not 899
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S205	2	Bagasse	WP	5	100	0	899
S205	3	Bagasse	WP	5	100	0	Not 899
S205	6	Bagasse	WP	5	100	0	No DNA
S205	9	Bagasse	WP	5	100	0	No DNA
S205	10	Bagasse	WP	5	100	0	No DNA
S205	12	Bagasse	WP	5	100	0	899
S205	21	Bagasse	WP	5	100	0	No DNA

S207		Bagasse	WP	75	25	26	Not 899	
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S207		Bagasse	WP	75	25	19		899
S207		Bagasse	WP	75	25	14		899
S207		Bagasse	WP	75	25	13		899
S208		Bagasse	WP	75	25	16		899
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S208		Bagasse	WP	75	25	14		899
S208		Bagasse	WP	75	25	12		899
S208		Bagasse	WP	75	25	3		899
S208		Bagasse	WP	75	25	1	Not 899	
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S211	3	Bagasse	WP	1	50	50		899
S211	4	Bagasse	WP	1	50	50	Not 899	
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S211	7	Bagasse	WP	1	50	50	Not 899	
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S211	9	Bagasse	WP	1	50	50	Not 899	
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S211	11	Bagasse	WP	1	50	50		899
S211	12	Bagasse	WP	1	50	50		899
S211	13	Bagasse	WP	1	50	50	Not 899	
S211	14	Bagasse	WP	1	50	50	Not 899	
S211	15	Bagasse	WP	1	50	50	Not 899	
S211	16	Bagasse	WP	1	50	50	Not 899	
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S211	19	Bagasse	WP	1	50	50	Not 899	
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S211	23	Bagasse	WP	1	50	50		899
S211	24	Bagasse	WP	1	50	50	Not 899	
S211	25	Bagasse	WP	1	50	50	No DNA	
S211	26	Bagasse	WP	1	50	50	Not 899	
S211	28	Bagasse	WP	1	50	50	Not 899	
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S213	1	Bagasse	WP	3	50	50		899
S213	2	Bagasse	WP	3	50	50	Not 899	
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S213	17	Bagasse	WP	3	50	50		899
S213	5	Bagasse	WP	3	50	50		899

S213	6	Bagasse	WP	3	50	50	Not 899	
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S213	18	Bagasse	WP	3	50	50		899
S213	19	Bagasse	WP	3	50	50	Not 899	
S213	20	Bagasse	WP	3	50	50		899
S213	21	Bagasse	WP	3	50	50		899
S213	22	Bagasse	WP	3	50	50		899
S213	23	Bagasse	WP	3	50	50	Not 899	
S215	1	Bagasse	WP	5	50	50	Not 899	
S215	2	Bagasse	WP	5	50	50	No DNA	
S215	4	Bagasse	WP	5	50	50	Not 899	
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S215	9	Bagasse	WP	5	50	50	Not 899	
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S216	9	Bagasse	WP	1	25	75	Not 899	
S217	3	Bagasse	WP	2	25	75	Not 899	
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S217	9	Bagasse	WP	2	25	75	Not 899	
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S218	6	Bagasse	WP	3	25	75	Not 899	
S218	7	Bagasse	WP	3	25	75		899
S218	8	Bagasse	WP	3	25	75	Not 899	
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S218	12	Bagasse	WP	3	25	75		899
S218	13	Bagasse	WP	3	25	75		899
S218	18	Bagasse	WP	3	25	75	Not 899	
S218	20	Bagasse	WP	3	25	75		899

S218	22	Bagasse	WP	3	25	75	899
S218	28	Bagasse	WP	3	25	75	899
S218	31	Bagasse	WP	3	25	75	899
S218	33	Bagasse	WP	3	25	75	899
S218	35	Bagasse	WP	3	25	75	899
S218	36	Bagasse	WP	3	25	75	Not 899
S218	38	Bagasse	WP	3	25	75	899
S218	39	Bagasse	WP	3	25	75	899
S218	42	Bagasse	WP	3	25	75	899
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S219	2	Bagasse	WP	4	25	75	Not 899
S219	3	Bagasse	WP	4	25	75	Not 899
S219	4	Bagasse	WP	4	25	75	Not 899
S219	5	Bagasse	WP	4	25	75	899
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S219	8	Bagasse	WP	4	25	75	Not 899
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S219	11	Bagasse	WP	4	25	75	No DNA
S219	12	Bagasse	WP	4	25	75	899
S219	13	Bagasse	WP	4	25	75	Not 899
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S220	9	Bagasse	WP	5	25	75	899
S220	15	Bagasse	WP	5	25	75	No DNA
S220	17	Bagasse	WP	5	25	75	No DNA
S220	18	Bagasse	WP	5	25	75	No DNA
S220	19	Bagasse	WP	5	25	75	No DNA
S220	23	Bagasse	WP	5	25	75	No DNA
S220	24	Bagasse	WP	5	25	75	No DNA
S220	27	Bagasse	WP	5	25	75	No DNA
S220	28	Bagasse	WP	5	25	75	No DNA
S220	40	Bagasse	WP	5	25	75	No DNA

Table 3.S15. Data for chapter 3 table 3.1 and figures 3.4, 3.7, S3.1, and S3.2.

Catchment	**Site**	**D_b (g cm^{-3})**	**Sample depth (cm)**	**PyC (%w/w)**	**PyC (Mg ha^{-1})**	**Ctot (% w/w)**	**Ctot (Gg ha^{-1})**	**Non-PyC C (%w/w)**	**Non-PyC C (Gg/ha)**	**PyC % Ctot**
FA	CH	0.8	0-15	2.43	29.19	8.60	103.21	6.17	74.02	28.28
FA	CH		15-30	0.48		6.00		5.52		8.05
FA	CH		30-60	0.35		2.94		2.60		11.80
FA	CH		60-100	0.34		2.29		1.95		14.92

FA	CH		100-200	0.19		0.99		0.80		19.52
FA	CH	0.8	0-15	0.95	11.38	6.88	82.62	5.94	71.23	13.78
FA	CH		15-30	1.14		7.69		6.55		14.79
FA	CH		30-60	0.56		4.88		4.31		11.55
FA	CH		60-100	0.33		2.61		2.28		12.68
FA	CH		100-200	0.33		1.82		1.49		17.95
FA	CH	0.8	0-15	0.64	7.64	5.03	60.35	4.39	52.70	12.66
FA	CH		15-30	0.72		5.27		4.55		13.65
FA	CH		30-60	0.51		4.32		3.81		11.76
FA	CH		60-100	0.42		3.31		2.89		12.80
FA	CH		100-200	0.24		1.43		1.19		16.92
FA	CH	0.8	0-15	1.69	20.25	7.81	93.75	6.13	73.50	21.60
FA	CH		15-30	0.97		8.42		7.45		11.54
FA	CH		30-60	0.53		4.38		3.85		12.04
FA	CH		60-100	0.41		2.74		2.33		15.02
FA	CH		100-200	0.33		1.80		1.46		18.61
FA	CH	0.8	0-15	0.56	6.68	6.53	78.41	5.98	71.73	8.52
FA	CH		15-30	2.92		8.84		5.92		33.02
FA	CH		30-60	0.50		3.23		2.73		15.47
FA	CH		60-100	0.33		2.16		1.83		15.42
FA	CH		100-200	0.42		2.30		1.88		18.23
FA	CH	0.8	0-15	1.34	16.12	6.27	75.29	4.93	59.17	21.40
FA	CH		15-30	0.85		5.56		4.71		15.25
FA	CH		30-60	0.57		3.58		3.01		15.99
FA	CH		60-100	0.62		2.46		1.84		25.05
FA	CH		100-200	0.66		1.65		0.99		40.06
FA	CH	0.8	0-15	0.52	6.26	8.22	98.60	7.70	92.34	6.34
FA	CH		15-30	0.66		6.80		6.14		9.75
FA	CH		30-60	0.47		4.79		4.33		9.78
FA	CH		60-100	0.50		1.20		0.70		41.45
FA	CH		100-200	0.43		2.48		2.05		17.33
FA	CH	0.8	0-15	1.22	14.66	6.02	72.25	4.80	57.59	20.29
FA	CH		15-30	0.55		4.42		3.87		12.40
FA	CH		30-60	0.40		3.01		2.61		13.22
FA	CH		60-100	0.33		2.05		1.72		16.09
FA	CH		100-200	0.29		1.37		1.08		21.23
FA	CH	0.8	0-15	0.94	11.23	5.25	63.05	4.32	51.82	17.81
FA	CH		15-30	1.16		5.81		4.66		19.87
FA	CH		30-60	0.60		4.94		4.34		12.17
FA	CH		60-100	0.59		2.93		2.34		20.19
FA	CH		100-200	0.42		1.50		1.08		28.24
FA	CH	0.8	0-15	1.36	16.28	7.90	94.79	6.54	78.51	17.18

FA	CH		15-30	0.74		5.88		5.14		12.52
FA	CH		30-60	0.51		3.90		3.40		12.98
FA	CH		60-100	0.49		1.78		1.29		27.65
FA	CH		100-200	0.47		1.69		1.22		27.98
FA	CH	0.8	0-15	1.86	22.28	9.68	116.12	7.82	93.83	19.19
FA	CH		15-30	0.84		7.40		6.56		11.40
FA	CH		30-60	0.56		4.03		3.47		13.90
FA	CH		60-100	0.46		2.68		2.22		17.10
FA	CH		100-200	0.33		2.11		1.78		15.65
FA	CH	0.8	0-15	1.54	18.50	9.06	108.69	7.52	90.20	17.02
FA	CH		15-30	0.67		6.47		5.81		10.28
FA	CH		30-60	0.65		4.03		3.38		16.06
FA	CH		60-100	0.48		2.92		2.44		16.50
FA	CH		100-200	0.42		1.98		1.56		21.13
FA	CH	0.8	0-15	2.50	30.04	10.26	123.08	7.75	93.04	24.41
FA	CH		15-30	2.38		7.57		5.19		31.42
FA	CH		30-60	0.97		5.69		4.72		17.01
FA	CH		60-100	0.58		3.09		2.51		18.75
FA	CH		100-200	0.39		1.63		1.24		24.11
Fa	I	0.8	0-15	0.29	3.46	5.91	70.96	5.63	67.50	4.87
Fa	I		15-30	0.26		3.27		3.01		7.92
Fa	I		30-60	0.21		2.22		2.00		9.59
Fa	I		60-100	0.24		2.08		1.83		11.76
Fa	I		100-200	0.28		1.72		1.45		16.09
Fa	I	0.8	0-15	0.36	4.32	6.18	74.20	5.82	69.88	5.83
Fa	I		15-30	0.29		4.55		4.26		6.38
Fa	I		30-60	0.29		2.86		2.57		10.22
Fa	I		60-100	0.23		1.68		1.45		13.62
Fa	I		100-200	0.39		2.31		1.92		16.77
Fa	I	0.8	0-15	0.36	4.29	7.14	85.74	6.79	81.45	5.00
Fa	I		15-30	0.35		4.33		3.98		8.19
Fa	I		30-60	0.30		2.72		2.42		10.88
Fa	I		60-100	0.33		2.40		2.07		13.62
Fa	I		100-200	0.30		1.95		1.65		15.53
Fa	I	0.8	0-15	0.37	4.40	8.69	104.25	8.32	99.86	4.22
Fa	I		15-30	0.37		4.91		4.53		7.60
Fa	I		30-60	0.28		2.32		2.04		12.10
Fa	I		60-100	0.30		2.29		1.99		13.19
Fa	I		100-200	0.17		1.25		1.08		13.73
Fa	II	0.8	0-15	0.36	4.31	7.65	91.80	7.29	87.49	4.70
Fa	II		15-30	0.28		3.24		2.97		8.51
Fa	II		30-60	0.24		1.97		1.72		12.25

Fa	II		60-100	0.32		1.91		1.60		16.50
Fa	II		100-200	0.27		1.48		1.21		18.12
Fa	II	0.8	0-15	0.48	5.74	9.53	114.33	9.05	108.59	5.02
Fa	II		15-30	0.56		5.84		5.27		9.65
Fa	II		30-60	0.45		3.32		2.87		13.48
Fa	II		60-100	0.15		0.84		0.69		18.01
Fa	II		100-200	0.28		1.59		1.32		17.31
Fa	II	0.8	0-15	0.47	5.63	7.86	94.32	7.39	88.69	5.97
Fa	II		15-30	0.38		4.85		4.47		7.77
Fa	II		30-60	0.40		2.69		2.30		14.75
Fa	II		60-100	0.33		1.91		1.58		17.34
Fa	II		100-200	0.56		1.58		1.02		35.46
Fa	II	0.8	0-15	0.73	8.81	11.46	137.48	10.72	128.68	6.40
Fa	II		15-30	0.83		7.28		6.46		11.34
Fa	II		30-60	0.78		5.03		4.24		15.58
Fa	II		60-100	0.52		2.24		1.72		23.14
Fa	II		100-200	0.58		11.53		10.96		5.00
Fa	III	0.8	0-15	0.60	7.15	8.46	101.46	7.86	94.31	7.05
Fa	III		15-30	0.66		6.49		5.83		10.13
Fa	III		30-60	0.58		4.27		3.70		13.46
Fa	III		60-100	0.45		2.35		1.89		19.37
Fa	III		100-200	0.49		1.02		0.54		47.53
Fa	III	0.8	0-15	0.43	5.13	6.37	76.45	5.94	71.32	6.71
Fa	III		15-30	0.34		4.39		4.05		7.81
Fa	III		30-60	0.48		4.42		3.94		10.89
Fa	III		60-100	0.34		2.03		1.69		16.88
Fa	III		100-200	0.22		1.27		1.05		17.19
Fa	III	0.8	0-15	0.50	6.05	6.70	80.45	6.20	74.40	7.52
Fa	III		15-30	0.48		4.61		4.13		10.37
Fa	III		30-60	0.35		1.97		1.62		17.87
Fa	III		60-100	0.46		1.43		0.97		31.83
Fa	III		100-200	0.36		0.89		0.53		40.36
Fa	III	0.8	0-15	0.51	6.16	7.59	91.11	7.08	84.95	6.76
Fa	III		15-30	0.51		5.95		5.44		8.62
Fa	III		30-60	0.47		3.48		3.02		13.39
Fa	III		60-100	0.34		1.93		1.58		17.86
Fa	III		100-200	0.65		1.58		0.93		41.14
Fa	IV	0.8	0-15	0.37	4.45	6.23	74.71	5.86	70.27	5.95
Fa	IV		15-30	0.40		2.74		2.34		14.55
Fa	IV		30-60	0.96		8.47		7.51		11.33
Fa	IV		60-100	0.45		4.01		3.56		11.23

Fa	IV		100-200	0.18		0.93		0.74		19.87
Fa	IV	0.8	0-15	0.33	3.99	1.80	21.62	1.47	17.63	18.45
Fa	IV		15-30	0.70		3.77		3.07		18.60
Fa	IV		30-60	0.62		3.56		2.95		17.32
Fa	IV		60-100	0.26		1.33		1.06		19.95
Fa	IV		100-200	0.25		0.95		0.70		26.49
Fa	IV	0.8	0-15	0.42	5.01	8.23	98.79	7.81	93.78	5.07
Fa	IV		15-30	0.54		6.57		6.03		8.28
Fa	IV		30-60	0.54		3.44		2.90		15.73
Fa	IV		60-100	0.44		2.37		1.93		18.50
Fa	IV		100-200	0.51		1.53		1.02		33.45
Fa	IV	0.8	0-15	1.58	18.93	9.17	110.02	7.59	91.08	17.21
Fa	IV		15-30	1.36		6.32		4.96		21.48
Fa	IV		30-60	0.65		4.27		3.62		15.17
Fa	IV		60-100	0.55		3.06		2.51		18.00
Fa	IV		100-200	0.31		1.21		0.89		25.95
Fa	V	0.8	0-15	0.38	4.54	6.68	80.10	6.30	75.56	5.66
Fa	V		15-30	0.37		6.88		6.51		5.41
Fa	V		30-60	0.33		4.37		4.04		7.57
Fa	V		60-100	0.30		2.57		2.27		11.63
Fa	V		100-200	0.37		1.52		1.14		24.63
Fa	V	0.8	0-15	0.37	4.48	5.89	70.66	5.51	66.18	6.34
Fa	V		15-30	0.40		4.58		4.18		8.74
Fa	V		30-60	0.42		3.09		2.67		13.58
Fa	V		60-100	0.38		2.59		2.21		14.51
Fa	V		100-200	0.21		1.17		0.96		18.08
Fa	V	0.8	0-15	0.36	4.36	5.95	71.42	5.59	67.06	6.11
Fa	V		15-30	0.46		5.45		4.99		8.43
Fa	V		30-60	0.41		3.03		2.63		13.47
Fa	V		60-100	0.29		1.90		1.61		15.37
Fa	V		100-200	0.21		1.10		0.89		18.83
Fa	V	0.8	0-15	0.46	5.47	10.35	124.23	9.90	118.76	4.40
Fa	V		15-30	0.32		3.87		3.55		8.36
Fa	V		30-60	0.45		3.44		2.99		13.14
Fa	V		60-100	0.47		2.60		2.13		18.11
Fa	V		100-200	0.31		1.42		1.11		21.56
Fb	IBC	0.8	0-15	0.22	2.64	4.22	50.64	4.00	48.00	5.21
Fb	IBC		15-30	0.24		3.07		2.83		7.72
Fb	IBC		30-60	0.23		1.94		1.71		11.77
Fb	IBC		60-100	0.15		0.72		0.57		20.32
Fb	IBC		100-200	0.05		0.56		0.52		8.47
Fb	IBC	0.8	0-15	0.25	3.03	5.69	68.29	5.44	65.25	4.44

Fb	IBC		15-30	0.24		2.50		2.26		9.56
Fb	IBC		30-60	0.21		2.29		2.07		9.38
Fb	IBC		60-100	0.12		0.66		0.54		17.54
Fb	IBC		100-200	0.09		0.93		0.84		9.73
Fb	IBC	0.8	0-15	0.27	3.28	5.81	69.76	5.54	66.48	4.70
Fb	IBC		15-30	0.26		3.26		3.00		8.06
Fb	IBC		30-60	0.12		1.19		1.07		10.48
Fb	IBC		60-100	0.11		0.75		0.64		14.85
Fb	IBC		100-200	0.18		2.94		2.75		6.21
Fb	IBC	0.8	0-20	0.27	3.30	6.75	80.99	6.47	77.69	4.07
Fb	IBC		15-30	0.25		3.47		3.23		7.08
Fb	IBC		30-60	0.21		2.19		1.99		9.46
Fb	IBC		60-100	0.17		0.90		0.72		19.38
Fb	IBC		100-200	0.44		1.74		1.29		25.53
Fb	I	0.8	0-15	0.23	2.75	6.73	80.75	6.50	78.00	3.41
Fb	I		15-30	0.12		1.80		1.67		6.80
Fb	I		30-60	0.08		0.66		0.58		12.67
Fb	I		60-100	0.05		0.45		0.39		12.16
Fb	I		100-200	0.22		1.46		1.24		15.22
Fb	I	0.8	0-15	0.28	3.32	6.14	73.70	5.87	70.38	4.50
Fb	I		15-30	0.23		2.70		2.47		8.61
Fb	I		30-60	0.19		1.15		0.96		16.81
Fb	I		60-100	0.12		0.98		0.86		12.01
Fb	I		100-200	0.05		0.45		0.40		11.49
Fb	I	0.8	0-15	0.20	2.42	7.53	90.31	7.32	87.88	2.68
Fb	I		15-30	0.15		4.07		3.93		3.57
Fb	I		30-60	0.08		1.08		1.00		7.30
Fb	I		60-100	0.05		0.74		0.68		7.12
Fb	I		100-200	0.05		0.64		0.59		8.29
Fb	I	0.8	0-15	0.30	3.54	9.04	108.43	8.74	104.89	3.27
Fb	I		15-30	0.25		5.61		5.36		4.39
Fb	I		30-60	0.14		1.41		1.27		10.14
Fb	I		60-100	0.07		0.87		0.80		8.30
Fb	I		100-200	0.08		1.12		1.04		7.18
Fb	IIBC	0.8	0-15	0.25	3.02	6.55	78.57	6.30	75.55	3.85
Fb	IIBC		15-30	0.31		5.71		5.40		5.47
Fb	IIBC		30-60	0.35		3.76		3.42		9.28
Fb	IIBC		60-100	0.15		1.30		1.15		11.42
Fb	IIBC		100-200	0.10		1.82		1.72		5.39
Fb	IIBC	0.8	0-15	0.33	3.98	7.75	93.04	7.42	89.06	4.27
Fb	IIBC		15-30	0.32		6.20		5.88		5.10
Fb	IIBC		30-60	0.29		3.86		3.57		7.59

Fb	IIBC		60-100	0.17		1.62		1.45		10.37
Fb	IIBC		100-200	0.09		0.92		0.83		9.66
Fb	IIBC	0.8	0-15	0.77	9.29	6.02	72.24	5.25	62.94	12.87
Fb	IIBC		15-30	0.32		7.46		7.14		4.32
Fb	IIBC		30-60	0.26		3.45		3.19		7.54
Fb	IIBC		60-100	0.26		2.30		2.04		11.49
Fb	IIBC		100-200	0.15		1.16		1.01		12.63
Fb	IIBC	0.8	0-15	0.27	3.19	5.60	67.15	5.33	63.96	4.74
Fb	IIBC		15-30	0.20		2.22		2.02		9.05
Fb	IIBC		30-60	0.23		2.67		2.44		8.62
Fb	IIBC		60-100	0.26		3.18		2.92		8.09
Fb	IIBC		100-200	0.10		1.19		1.08		8.82
Fb	II	0.8	0-15	0.56	6.75	5.56	66.73	5.00	59.98	10.11
Fb	II		15-30	0.61		4.06		3.45		15.09
Fb	II		30-60	0.47		4.07		3.60		11.51
Fb	II		60-100	0.37		3.05		2.68		12.25
Fb	II		100-200	0.06		0.40		0.33		16.02
Fb	II	0.8	0-15	0.30	3.54	7.74	92.88	7.45	89.34	3.81
Fb	II		15-30	0.31		5.12		4.82		5.97
Fb	II		30-60	0.34		3.63		3.29		9.42
Fb	II		60-100	0.19		1.29		1.10		14.84
Fb	II		100-200	0.06		0.64		0.58		9.17
Fb	II	0.8	0-15	0.29	3.51	6.37	76.43	6.08	72.92	4.59
Fb	II		15-30	0.32		4.17		3.85		7.61
Fb	II		30-60	0.28		2.22		1.94		12.71
Fb	II		60-100	0.14		1.12		0.98		12.60
Fb	II		100-200	0.07		0.79		0.72		8.77
Fb	II	0.8	0-15	0.28	3.39	8.97	107.68	8.69	104.30	3.15
Fb	II		15-30	0.18		5.27		5.08		3.49
Fb	II		30-60	0.15		1.89		1.74		7.72
Fb	II		60-100	0.09		0.88		0.78		10.58
Fb	II		100-200	0.13		1.59		1.46		8.31
Fb	IIIBC	0.8	0-15	0.45	5.39	5.13	61.60	4.68	56.20	8.76
Fb	IIIBC		15-30	0.36		3.81		3.45		9.34
Fb	IIIBC		30-60	0.30		2.41		2.11		12.26
Fb	IIIBC		60-100	0.10		0.68		0.58		14.97
Fb	IIIBC		100-200	0.10		0.75		0.65		13.58
Fb	IIIBC	0.8	0-15	0.39	4.72	3.29	39.46	2.89	34.74	11.96
Fb	IIIBC		15-30	0.78		8.41		7.63		9.28
Fb	IIIBC		30-60	0.29		2.20		1.91		13.11

Fb	IIIBC		60-100	0.07		0.52		0.45		12.90
Fb	IIIBC		100-200	0.08		0.64		0.57		11.98
Fb	IIIBC	0.8	0-15	0.28	3.33	3.05	36.59	2.77	33.26	9.10
Fb	IIIBC		15-30	0.32		6.97		6.65		4.54
Fb	IIIBC		30-60	0.33		2.27		1.94		14.53
Fb	IIIBC		60-100	0.20		1.31		1.11		15.50
Fb	IIIBC		100-200	0.07		0.79		0.72		8.81
Fb	IIIBC	0.8	0-15	0.34	4.08	4.18	50.21	3.84	46.13	8.12
Fb	IIIBC		15-30	0.39		3.91		3.52		9.90
Fb	IIIBC		30-60	0.29		3.33		3.04		8.68
Fb	IIIBC		60-100	0.13		0.83		0.70		15.50
Fb	IIIBC		100-200	0.09		0.66		0.57		13.06
Fb	III	0.8	0-15	0.29	3.52	6.16	73.96	5.87	70.44	4.76
Fb	III		15-30	0.26		2.90		2.63		9.15
Fb	III		30-60	0.27		2.26		1.99		11.79
Fb	III		60-100	0.23		1.54		1.31		14.72
Fb	III		100-200	0.08		0.95		0.87		8.71
Fb	III	0.8	0-15	0.32	3.90	6.92	83.00	6.59	79.10	4.69
Fb	III		15-30	0.20		1.63		1.43		12.34
Fb	III		30-60	0.24		2.83		2.59		8.46
Fb	III		60-100	0.10		0.73		0.63		13.91
Fb	III		100-200	0.10		0.97		0.88		9.96
Fb	III	0.8	0-15	0.31	3.72	8.40	100.76	8.09	97.04	3.69
Fb	III		15-30	0.27		3.85		3.58		6.93
Fb	III		30-60	0.26		2.61		2.35		9.94
Fb	III		60-100	0.14		1.10		0.97		12.24
Fb	III		100-200	0.10		1.24		1.14		7.94
Fb	III	0.8	0-15	0.32	3.85	9.85	118.19	9.53	114.34	3.26
Fb	III		15-30	0.29		5.11		4.82		5.75
Fb	III		30-60	0.26		2.71		2.45		9.75
Fb	III		60-100	0.15		1.37		1.23		10.67
Fb	III		100-200	0.08		0.78		0.71		9.94
Fb	IVBC	0.8	0-20	0.16	1.89	5.10	61.16	4.94	59.26	3.10
Fb	IVBC		15-30	0.08		1.57		1.48		5.35
Fb	IVBC		30-60	0.10		2.18		2.07		4.79
Fb	IVBC		60-100	0.04		0.60		0.55		7.54
Fb	IVBC		100-200	0.07		1.18		1.11		6.06
Fb	IVBC	0.8	0-15	0.16	1.93	4.78	57.36	4.62	55.44	3.36

Fb	IVBC		15-30	0.11		2.41		2.30		4.62
Fb	IVBC		30-60	0.08		1.09		1.00		7.78
Fb	IVBC		60-100	0.05		0.66		0.61		7.24
Fb	IVBC		100-200	0.05		0.61		0.57		7.51
Fb	IVBC	0.8	0-15	0.13	1.61	4.40	52.77	4.26	51.16	3.05
Fb	IVBC		15-30	0.14		2.88		2.74		4.99
Fb	IVBC		30-60	0.13		2.10		1.98		6.04
Fb	IVBC		60-100	0.07		1.18		1.11		5.97
Fb	IVBC		100-200	0.04		0.63		0.58		6.84
Fb	IVBC	0.8	0-15	0.13	1.56	4.01	48.06	3.88	46.50	3.25
Fb	IVBC		15-30	0.13		4.01		3.88		3.25
Fb	IVBC		30-60	0.08		1.09		1.01		7.28
Fb	IVBC		60-100	0.07		0.88		0.81		7.99
Fb	IVBC		100-200	0.05		0.67		0.62		6.99
Fb	IV	0.8	0-15	0.21	2.50	5.63	67.52	5.42	65.02	3.70
Fb	IV		15-30	0.24		3.29		3.05		7.42
Fb	IV		30-60	0.15		1.65		1.50		9.07
Fb	IV		60-100	0.11		1.40		1.29		7.52
Fb	IV		100-200	0.17		3.68		3.51		4.73
Fb	IV	0.8	0-15	0.26	3.08	5.69	68.31	5.44	65.24	4.50
Fb	IV		15-30	0.22		3.18		2.96		6.96
Fb	IV		30-60	0.16		1.39		1.23		11.19
Fb	IV		60-100	0.09		0.54		0.45		16.29
Fb	IV		100-200	0.09		0.87		0.78		10.09
Fb	IV	0.8	0-15	0.27	3.20	5.88	70.51	5.61	67.31	4.54
Fb	IV		15-30	0.23		3.27		3.04		7.10
Fb	IV		30-60	0.14		1.13		0.99		12.50
Fb	IV		60-100	0.12		0.84		0.72		13.75
Fb	IV		100-200	0.20		0.89		0.69		22.68
Fb	IV	0.8	0-15	0.26	3.16	4.98	59.72	4.71	56.55	5.30
Fb	IV		15-30	0.21		2.43		2.23		8.58
Fb	IV		30-60	0.18		1.10		0.92		16.27
Fb	IV		60-100	0.15		0.68		0.53		21.90
Fb	IV		100-200	0.27		1.27		1.00		21.35
10a	I	0.91	0-15	0.41	5.61	3.98	54.35	3.57	48.74	10.32
10a	I		15-30	0.51		5.03		4.53		10.10
10a	I		30-60	0.37		3.61		3.24		10.35
10a	I		60-100	0.15		2.19		2.04		7.01
10a	I		100-200	0.17		1.46		1.29		11.66

10a	I	0.91	0-15	0.25	3.35	5.00	68.20	4.75	64.85	4.92
10a	I		15-30	0.19		4.04		3.85		4.80
10a	I		30-60	0.15		3.86		3.70		3.98
10a	I		60-100	0.14		1.61		1.47		8.68
10a	I		100-200	0.10		1.05		0.95		9.16
10a	I	0.91	0-15	0.38	5.18	5.74	78.31	5.36	73.13	6.62
10a	I		15-30	0.21		5.92		5.71		3.62
10a	I		30-60	0.20		3.03		2.84		6.45
10a	I		60-100	0.13		1.61		1.49		7.88
10a	I		100-200	0.05		0.64		0.59		7.62
10a	I	0.91	0-15	0.23	3.07	3.75	51.17	3.52	48.09	6.01
10a	I		15-30	0.23		3.37		3.15		6.68
10a	I		30-60	0.20		2.49		2.29		8.19
10a	I		60-100	0.12		1.05		0.93		11.56
10a	I		100-200	0.16		1.41		1.25		11.09
10a	II	0.91	0-15	0.27	3.66	4.82	65.73	4.55	62.07	5.56
10a	II		15-30	0.26		4.13		3.87		6.37
10a	II		30-60	0.21		3.06		2.84		7.00
10a	II		60-100	0.46		3.34		2.88		13.84
10a	II		100-200	0.11		0.88		0.77		12.75
10a	II	0.91	0-15	0.18	2.48	2.44	33.29	2.26	30.81	7.46
10a	II		15-30	0.23		3.27		3.03		7.19
10a	II		30-60	0.14		2.00		1.85		7.12
10a	II		60-100	0.10		1.79		1.69		5.85
10a	II		100-200	0.06		0.62		0.56		10.25
10a	II	0.91	0-15	0.25	3.41	4.98	67.92	4.73	64.52	5.01
10a	II		15-30	0.21		4.03		3.81		5.31
10a	II		30-60	0.19		2.62		2.43		7.31
10a	II		60-100	0.22		3.09		2.87		7.18
10a	II		100-200	0.28		2.57		2.29		10.88
10a	II	0.91	0-15	0.14	1.87	3.69	50.34	3.55	48.47	3.72
10a	II		15-30	0.16		3.94		3.78		4.06
10a	II		30-60	0.08		1.32		1.25		5.98
10a	II		60-100	0.18		2.51		2.33		7.21
10a	II		100-200	0.03		0.33		0.30		8.27
10a	III	0.91	0-15	0.41	5.60	6.35	86.62	5.94	81.02	6.46
10a	III		15-30	0.43		5.44		5.01		7.89
10a	III		30-60	0.37		3.19		2.82		11.54
10a	III		60-100	0.27		1.65		1.38		16.52
10a	III		100-200	0.28		1.10		0.82		25.46
10a	III	0.91	0-15	0.31	4.18	6.36	86.81	6.05	82.62	4.82
10a	III		15-30	0.30		5.29		5.00		5.57

10a	III		30-60	0.26		2.59		2.33		9.95
10a	III		60-100	0.15		1.25		1.10		12.01
10a	III		100-200	0.18		1.44		1.26		12.52
10a	III	0.91	0-15	0.41	5.58	5.39	73.61	4.98	68.03	7.58
10a	III		15-30	0.34		4.48		4.15		7.54
10a	III		30-60	0.24		2.50		2.27		9.40
10a	III		60-100	0.19		1.69		1.50		11.47
10a	III		100-200	0.17		1.13		0.96		14.90
10a	III	0.91	0-15	0.33	4.45	5.70	77.84	5.38	73.39	5.71
10a	III		15-30	0.28		3.66		3.38		7.75
10a	III		30-60	0.23		2.01		1.78		11.38
10a	III		60-100	0.20		1.40		1.20		14.28
10a	III		100-200	0.13		0.75		0.62		17.88
10a	IV	0.91	0-15	0.39	5.27	6.19	84.43	5.80	79.16	6.24
10a	IV		15-30	0.38		5.90		5.52		6.45
10a	IV		30-60	0.34		3.55		3.21		9.62
10a	IV		60-100	0.24		1.58		1.33		15.50
10a	IV		100-200	0.24		1.42		1.18		16.98
10a	IV	0.91	0-15	0.39	5.32	6.25	85.25	5.86	79.92	6.24
10a	IV		15-30	0.32		4.73		4.41		6.82
10a	IV		30-60	0.34		2.43		2.09		14.08
10a	IV		60-100	0.34		3.12		2.78		10.87
10a	IV		100-200	0.33		3.55		3.22		9.21
10a	IV	0.91	0-15	0.52	7.16	5.52	75.36	5.00	68.20	9.50
10a	IV		15-30	0.49		4.63		4.14		10.50
10a	IV		30-60	0.30		2.66		2.36		11.39
10a	IV		60-100	0.26		1.83		1.57		14.21
10a	IV		100-200	0.18		0.97		0.79		18.61
10a	IV	0.91	0-15	0.62	8.47	6.55	89.46	5.93	80.99	9.47
10a	IV		15-30	0.45		4.85		4.40		9.27
10a	IV		30-60	0.29		2.21		1.92		13.25
10a	IV		60-100	0.15		0.96		0.81		15.22
10a	IV		100-200	0.18		1.27		1.09		14.20
10b	I	0.91	0-15	0.09	1.20	1.29	17.61	1.20	16.41	6.83
10b	I		15-30	0.09		1.46		1.37		6.18
10b	I		30-60	0.05		0.53		0.48		10.09
10b	I		60-100	0.05		0.43		0.39		10.53
10b	I		100-200	0.05		0.39		0.35		11.51
10b	I	0.91	0-15	0.13	1.71	2.61	35.62	2.48	33.91	4.81
10b	I		15-30	0.19		2.50		2.31		7.76
10b	I		30-60	0.20		1.46		1.27		13.39
10b	I		60-100	0.09		1.11		1.02		8.52

10b	I		100-200	0.13		2.17		2.04		5.90
10b	I	0.91	0-15	0.05	0.64	0.56	7.69	0.52	7.05	8.31
10b	I		15-30	0.16		1.80		1.63		9.02
10b	I		30-60	0.08		0.79		0.70		10.44
10b	I		60-100	0.04		0.38		0.34		10.26
10b	I		100-200	0.04		0.35		0.31		10.15
10b	I	0.91	0-15	0.26	3.55	2.81	38.29	2.54	34.74	9.28
10b	I		15-30	0.15		2.05		1.90		7.34
10b	I		30-60	0.09		1.56		1.47		5.47
10b	I		60-100	0.05		0.78		0.73		6.29
10b	I		100-200	0.06		0.76		0.70		8.30
10b	II	0.91	0-15	0.26	3.57	3.26	44.46	3.00	40.89	8.03
10b	II		15-30	0.21		4.27		4.05		4.99
10b	II		30-60	0.27		3.75		3.48		7.24
10b	II		60-100	0.24		2.46		2.22		9.75
10b	II		100-200	0.16		3.86		3.70		4.16
10b	II	0.91	0-15	0.16	2.25	1.94	26.43	1.77	24.18	8.50
10b	II		15-30	0.13		2.95		2.82		4.51
10b	II		30-60	0.13		1.50		1.36		8.97
10b	II		60-100	0.19		1.66		1.47		11.41
10b	II		100-200	0.22		1.68		1.46		13.22
10b	II	0.91	0-15	0.22	2.99	3.75	51.20	3.53	48.21	5.84
10b	II		15-30	0.20		3.88		3.68		5.15
10b	II		30-60	0.16		2.25		2.09		7.12
10b	II		60-100	0.22		2.08		1.85		10.76
10b	II		100-200	0.09		0.98		0.89		8.90
10b	II	0.91	0-15	0.24	3.28	2.72	37.14	2.48	33.87	8.82
10b	II		15-30	0.23		2.22		1.99		10.47
10b	II		30-60	0.20		2.30		2.10		8.71
10b	II		60-100	0.23		2.26		2.03		10.23
10b	II		100-200	0.23		1.78		1.55		13.11
10b	III	0.91	0-15	0.27	3.67	5.54	75.62	5.27	71.95	4.85
10b	III		15-30	0.32		4.56		4.24		7.00
10b	III		30-60	0.27		2.21		1.95		12.07
10b	III		60-100	0.18		1.26		1.08		14.10
10b	III		100-200	0.14		0.83		0.69		16.68
10b	III	0.91	0-15	0.45	6.21	6.41	87.51	5.96	81.30	7.09
10b	III		15-30	0.36		4.79		4.43		7.44
10b	III		30-60	0.32		4.01		3.69		8.00
10b	III		60-100	0.28		2.10		1.82		13.20
10b	III		100-200	0.27		1.45		1.18		18.82
10b	III	0.91	0-15	0.35	4.73	6.37	86.90	6.02	82.17	5.44

10b	III		15-30	0.40		6.03		5.64		6.58
10b	III		30-60	0.35		3.87		3.52		8.93
10b	III		60-100	0.25		2.07		1.83		11.81
10b	III		100-200	0.21		1.66		1.45		12.55
10b	III	0.91	0-15	0.46	6.32	7.84	107.07	7.38	100.75	5.90
10b	III		15-30	0.46		7.04		6.58		6.50
10b	III		30-60	0.36		3.24		2.88		11.02
10b	III		60-100	0.36		2.08		1.71		17.51
10b	III		100-200	0.28		1.54		1.26		18.20
10b	IV	0.91	0-15	0.53	7.23	6.90	94.15	6.37	86.92	7.68
10b	IV		15-30	0.49		5.01		4.52		9.72
10b	IV		30-60	0.44		2.92		2.48		15.00
10b	IV		60-100	0.32		1.62		1.31		19.59
10b	IV		100-200	0.57		2.56		1.99		22.25
10b	IV	0.91	0-15	0.74	10.13	8.32	113.57	7.58	103.45	8.92
10b	IV		15-30	0.68		7.59		6.91		9.00
10b	IV		30-60	0.52		5.39		4.87		9.67
10b	IV		60-100	0.28		2.08		1.79		13.66
10b	IV		100-200	0.61		3.04		2.43		20.17
10b	IV	0.91	0-15	0.41	5.63	6.66	90.89	6.25	85.26	6.19
10b	IV		15-30	0.38		5.36		4.98		7.13
10b	IV		30-60	0.33		2.86		2.54		11.41
10b	IV		60-100	0.26		1.98		1.72		12.95
10b	IV		100-200	0.19		1.19		0.99		16.37
10b	IV	0.91	0-15	0.36	4.95	4.93	67.28	4.57	62.34	7.35
10b	IV		15-30	0.36		4.17		3.82		8.53
10b	IV		30-60	0.28		2.16		1.88		13.05
10b	IV		60-100	0.26		1.76		1.49		15.01
10b	IV		100-200	0.14		1.01		0.87		13.65
10b	V	0.91	0-15	0.31	4.25	5.01	68.36	4.70	64.11	6.22
10b	V		15-30	0.41		5.86		5.46		6.95
10b	V		30-60	0.40		2.31		1.91		17.42
10b	V		60-100	0.29		2.14		1.85		13.36
10b	V		100-200	0.26		1.65		1.39		15.95
10b	V	0.91	0-15	0.38	5.15	6.16	84.06	5.78	78.91	6.13
10b	V		15-30	0.39		5.12		4.73		7.62
10b	V		30-60	0.29		3.17		2.88		9.28
10b	V		60-100	0.34		2.35		2.00		14.55
10b	V		100-200	0.30		1.69		1.39		17.53
10b	V	0.91	0-15	0.34	4.60	6.26	85.46	5.92	80.86	5.38
10b	V		15-30	0.44		5.79		5.35		7.63
10b	V		30-60	0.39		3.57		3.17		11.06

10b	V		60-100	0.32		1.87		1.55		17.10
10b	V		100-200	0.32		1.32		1.00		24.11
10b	V	0.91	0-15	0.42	5.80	6.32	86.30	5.90	80.50	6.72
10b	V		15-30	0.38		5.91		5.53		6.47
10b	V		30-60	0.36		4.33		3.97		8.21
10b	V		60-100	0.31		2.76		2.45		11.18
10b	V		100-200	0.21		1.69		1.47		12.64
10b	VI	0.91	0-15	0.37	5.00	6.91	94.38	6.55	89.38	5.30
10b	VI		15-30	0.34		6.29		5.94		5.48
10b	VI		30-60	0.37		4.99		4.61		7.51
10b	VI		60-100	0.34		3.43		3.09		9.97
10b	VI		100-200	0.22		1.68		1.46		13.05
10b	VI	0.91	0-15	0.40	5.44	8.19	111.82	7.79	106.38	4.87
10b	VI		15-30	0.35		5.70		5.35		6.08
10b	VI		30-60	0.31		3.77		3.46		8.33
10b	VI		60-100	0.40		3.17		2.77		12.53
10b	VI		100-200	0.27		2.39		2.12		11.49
10b	VI	0.91	0-15	0.28	3.75	5.68	77.58	5.41	73.83	4.84
10b	VI		15-30	0.39		6.42		6.03		6.09
10b	VI		30-60	0.26		2.68		2.42		9.74
10b	VI		60-100	0.27		1.81		1.55		14.65
10b	VI		100-200	0.24		1.69		1.45		14.20
10b	VI	0.91	0-15	0.31	4.21	5.88	80.32	5.58	76.11	5.24
10b	VI		15-30	0.41		6.00		5.59		6.90
10b	VI		30-60	0.35		3.82		3.47		9.24
10b	VI		60-100	0.30		2.18		1.88		13.77
10b	VI		100-200	0.31		2.16		1.84		14.58
16a	I	1.03	0-15	0.31	4.86	5.03	77.64	4.71	72.78	6.26
16a	I		15-30	0.28		3.52		3.24		7.96
16a	I		30-60	0.16		1.11		0.96		14.06
16a	I		60-100	0.06		0.47		0.41		11.74
16a	I		100-200	0.04		0.30		0.25		14.92
16a	I	1.03	0-15	0.40	6.18	7.16	110.65	6.76	104.47	5.59
16a	I		15-30	0.34		6.98		6.64		4.92
16a	I		30-60	0.39		5.10		4.71		7.59
16a	I		60-100	0.30		2.10		1.79		14.49
16a	I		100-200	0.07		0.48		0.41		13.58
16a	I	1.03	0-15	0.14	2.24	4.15	64.07	4.00	61.83	3.49
16a	I		15-30	0.13		2.79		2.65		4.79
16a	I		30-60	0.15		1.90		1.75		7.98
16a	I		60-100	0.05		0.48		0.42		11.07
16a	I		100-200	0.03		0.52		0.48		6.20

16a	I	1.03	0-15	0.22	3.37	6.13	94.68	5.91	91.30	3.56
16a	I		15-30	0.25		4.76		4.51		5.26
16a	I		30-60	0.33		1.98		1.65		16.45
16a	I		60-100	0.10		0.64		0.53		16.48
16a	I		100-200	0.05		0.20		0.15		23.16
16a	II	1.03	0-15	0.34	5.27	6.94	107.29	6.60	102.02	4.91
16a	II		15-30	0.30		6.21		5.91		4.88
16a	II		30-60	0.34		4.36		4.02		7.74
16a	II		60-100	0.28		1.99		1.71		13.88
16a	II		100-200	0.09		1.15		1.06		7.88
16a	II	1.03	0-15	0.25	3.80	4.14	63.93	3.89	60.13	5.94
16a	II		15-30	0.31		4.48		4.16		7.02
16a	II		30-60	0.21		2.43		2.22		8.50
16a	II		60-100	0.11		1.16		1.05		9.46
16a	II		100-200	0.09		0.90		0.81		9.65
16a	II	1.03	0-15	0.30	4.58	4.01	61.99	3.72	57.41	7.39
16a	II		15-30	0.37		3.04		2.67		12.07
16a	II		30-60	0.19		1.43		1.24		13.22
16a	II		60-100	0.09		1.04		0.96		8.43
16a	II		100-200	0.09		0.92		0.82		10.17
16a	II	1.03	0-15	0.27	4.21	5.37	82.91	5.09	78.71	5.08
16a	II		15-30	0.24		3.80		3.56		6.25
16a	II		30-60	0.24		2.20		1.97		10.76
16a	II		60-100	0.15		1.24		1.09		11.73
16a	II		100-200	0.14		1.50		1.35		9.43
16a	III	1.03	0-15	0.23	3.52	3.76	58.08	3.53	54.56	6.06
16a	III		15-30	0.23		2.46		2.22		9.42
16a	III		30-60	0.12		1.20		1.08		10.25
16a	III		60-100	0.13		1.14		1.01		11.07
16a	III		100-200	0.29		4.09		3.80		6.98
16a	III	1.03	0-15	0.10	1.56	0.84	13.01	0.74	11.45	11.99
16a	III		15-30	0.26		3.84		3.58		6.86
16a	III		30-60	0.24		3.11		2.87		7.76
16a	III		60-100	0.24		2.62		2.38		9.28
16a	III		100-200	0.20		1.82		1.61		11.06
16a	III	1.03	0-15	0.36	5.50	6.94	107.19	6.58	101.69	5.13
16a	III		15-30	0.26		4.33		4.08		5.90
16a	III		30-60	0.35		4.15		3.80		8.37
16a	III		60-100	0.27		2.43		2.16		11.03
16a	III		100-200	0.11		1.17		1.06		9.16
16a	III	1.03	0-15	0.22	3.37	4.14	63.92	3.92	60.55	5.27
16a	III		15-30	0.22		3.58		3.36		6.17

16a	III		30-60	0.26		2.87		2.61		9.03
16a	III		60-100	0.19		1.85		1.66		10.38
16a	III		100-200	0.35		1.58		1.24		21.84
16a	IV	1.03	0-15	0.23	3.52	4.30	66.50	4.08	62.98	5.29
16a	IV		15-30	0.23		2.99		2.76		7.71
16a	IV		30-60	0.19		2.39		2.20		8.10
16a	IV		60-100	0.28		2.30		2.02		11.96
16a	IV		100-200	0.14		1.12		0.98		12.71
16a	IV	1.03	0-15	0.18	2.79	3.66	56.57	3.48	53.78	4.93
16a	IV		15-30	0.20		3.41		3.21		5.88
16a	IV		30-60	0.26		2.62		2.36		9.79
16a	IV		60-100	0.17		1.72		1.55		9.74
16a	IV		100-200	0.18		1.82		1.63		10.01
16a	IV	1.03	0-15	0.31	4.79	3.80	58.72	3.49	53.93	8.15
16a	IV		15-30	0.31		4.04		3.73		7.68
16a	IV		30-60	0.19		2.47		2.28		7.73
16a	IV		60-100	0.24		2.29		2.05		10.35
16a	IV		100-200	0.19		1.74		1.55		10.69
16a	IV	1.03	0-15	0.22	3.47	4.46	68.85	4.23	65.38	5.04
16a	IV		15-30	0.19		2.85		2.66		6.63
16a	IV		30-60	0.19		2.25		2.06		8.43
16a	IV		60-100	0.18		1.76		1.59		9.95
16a	IV		100-200	0.08		0.98		0.89		8.63
16a	V	1.03	0-15	0.22	3.45	6.27	96.84	6.04	93.39	3.56
16a	V		15-30	0.16		2.90		2.75		5.38
16a	V		30-60	0.17		2.76		2.59		6.25
16a	V		60-100	0.13		1.64		1.52		7.82
16a	V		100-200	0.09		1.38		1.29		6.64
16a	V	1.03	0-20	0.19	2.88	3.64	56.25	3.45	53.37	5.11
16a	V		15-30	0.21		4.09		3.88		5.10
16a	V		30-60	0.20		4.07		3.86		5.04
16a	V		60-100	0.12		1.63		1.50		7.48
16a	V		100-200	0.08		1.07		1.00		7.14
16a	V	1.03	0-15	0.20	3.10	5.37	83.04	5.17	79.94	3.73
16a	V		15-30	0.18		3.48		3.30		5.21
16a	V		30-60	0.21		2.85		2.64		7.25
16a	V		60-100	0.17		2.10		1.94		7.93
16a	V		100-200	0.09		1.72		1.62		5.46
16a	V	1.03	0-15	0.26	4.07	7.73	119.37	7.46	115.30	3.41
16a	V		15-30	0.23		3.01		2.78		7.72
16a	V		30-60	0.29		5.77		5.48		4.99
16a	V		60-100	0.10		1.06		0.96		9.06

16a	V		100-200	0.11		1.68		1.57		6.57
16b	I	1.03	0-15	0.19	2.97	5.55	85.76	5.36	82.79	3.46
16b	I		15-30	0.16		3.37		3.20		4.90
16b	I		30-60	0.09		1.57		1.49		5.56
16b	I		60-100	0.09		1.34		1.25		6.99
16b	I		100-200	0.05		0.51		0.46		8.92
16b	I	1.03	0-15	0.19	2.91	3.18	49.10	2.99	46.19	5.93
16b	I		15-30	0.16		2.78		2.63		5.66
16b	I		30-60	0.12		1.90		1.78		6.52
16b	I		60-100	0.09		0.74		0.65		11.67
16b	I		100-200	0.07		0.40		0.33		17.93
16b	I	1.03	0-15	0.14	2.16	4.19	64.66	4.05	62.50	3.35
16b	I		15-30	0.11		2.52		2.41		4.30
16b	I		30-60	0.09		1.41		1.32		6.47
16b	I		60-100	0.04		0.64		0.60		6.39
16b	I		100-200	0.05		0.69		0.64		7.00
16b	I	1.03	0-15	0.21	3.31	10.25	158.35	10.03	155.04	2.09
16b	I		15-30	0.11		2.79		2.68		3.79
16b	I		30-60	0.06		0.80		0.74		7.89
16b	I		60-100	0.05		0.46		0.40		11.98
16b	I		100-200	0.05		0.81		0.75		6.59
16b	II	1.03	0-15	0.29	4.55	11.35	175.42	11.06	170.87	2.59
16b	II		15-30	0.12		3.38		3.26		3.67
16b	II		30-60	0.09		2.18		2.10		4.03
16b	II		60-100	0.09		1.96		1.87		4.77
16b	II		100-200	0.08		1.52		1.44		5.32
16b	II	1.03	0-15	0.13	2.00	3.88	59.87	3.75	57.87	3.35
16b	II		15-30	0.12		3.38		3.25		3.63
16b	II		30-60	0.10		1.92		1.82		5.06
16b	II		60-100	0.08		1.68		1.60		4.78
16b	II		100-200	0.11		2.03		1.92		5.18
16b	II	1.03	0-15	0.25	3.90	7.07	109.31	6.82	105.41	3.56
16b	II		15-30	0.22		5.74		5.53		3.77
16b	II		30-60	0.16		4.95		4.79		3.23
16b	II		60-100	0.11		2.40		2.29		4.47
16b	II		100-200	0.03		0.51		0.47		6.43
16b	II	1.03	0-20	0.17	2.59	7.62	117.67	7.45	115.08	2.20
16b	II		15-30	0.10		2.46		2.36		4.23
16b	II		30-60	0.09		1.58		1.50		5.52
16b	II		60-100	0.11		1.99		1.88		5.49
16b	II		100-200	0.05		0.86		0.81		6.33

16b	III	1.03	0-15	0.21	3.23	2.39	36.97	2.18	33.75	8.72
16b	III		15-30	0.08		1.08		1.01		6.96
16b	III		30-60	0.08		1.27		1.20		5.93
16b	III		60-100	0.24		5.51		5.26		4.42
16b	III		100-200	0.27		4.80		4.53		5.59
16b	III	1.03	0-15	0.24	3.66	2.90	44.73	2.66	41.08	8.17
16b	III		15-30	0.07		0.87		0.80		8.10
16b	III		30-60	0.15		2.58		2.44		5.63
16b	III		60-100	0.27		5.98		5.71		4.48
16b	III		100-200	0.19		3.59		3.39		5.42
16b	III	1.03	0-15	0.21	3.18	4.37	67.51	4.16	64.33	4.71
16b	III		15-30	0.19		3.61		3.43		5.13
16b	III		30-60	0.20		3.70		3.50		5.48
16b	III		60-100	0.18		1.83		1.66		9.68
16b	III		100-200	0.06		0.74		0.69		7.64
16b	III	1.03	0-15	0.22	3.39	5.71	88.17	5.49	84.78	3.85
16b	III		15-30	0.20		3.71		3.50		5.46
16b	III		30-60	0.19		2.64		2.45		7.25
16b	III		60-100	0.10		1.22		1.12		8.40
16b	III		100-200	0.06		0.80		0.74		8.08
16b	IV	1.03	0-15	0.19	2.86	3.76	58.02	3.57	55.16	4.93
16b	IV		15-30	0.22		4.68		4.46		4.75
16b	IV		30-60	0.29		3.49		3.20		8.31
16b	IV		60-100	0.18		2.30		2.11		8.03
16b	IV		100-200	0.08		1.58		1.50		4.91
16b	IV	1.03	0-15	0.21	3.24	4.96	76.62	4.75	73.39	4.23
16b	IV		15-30	0.23		3.93		3.69		5.97
16b	IV		30-60	0.22		2.47		2.25		8.88
16b	IV		60-100	0.18		1.72		1.54		10.52
16b	IV		100-200	0.07		0.96		0.89		7.39
16b	IV	1.03	0-15	0.22	3.39	3.71	57.38	3.49	53.99	5.91
16b	IV		15-30	0.27		4.69		4.41		5.81
16b	IV		30-60	0.16		3.29		3.13		4.92
16b	IV		60-100	0.10		1.31		1.20		7.98
16b	IV		100-200	0.06		1.17		1.11		5.14
16b	IV	1.03	0-15	0.22	3.40	2.38	36.77	2.16	33.37	9.25
16b	IV		15-30	0.21		3.03		2.83		6.81
16b	IV		30-60	0.29		2.98		2.69		9.67
16b	IV		100-200	0.21		1.99		1.78		10.62
16b	IV		100-200	0.10		1.06		0.96		9.69
62a	I	1.17	0-15	0.33	5.78	4.38	76.88	4.05	71.09	7.52
62a	I		15-30	0.29		3.76		3.48		7.60

62a	I		30-60	0.18		2.63		2.45		6.67
62a	I		60-100	0.19		1.18		1.00		15.70
62a	I		100-200	0.10		1.05		0.95		9.12
62a	I	1.17	0-15	0.22	3.81	3.00	52.58	2.78	48.77	7.24
62a	I		15-30	0.23		3.15		2.92		7.40
62a	I		30-60	0.15		2.09		1.94		7.16
62a	I		60-100	0.09		0.93		0.84		9.98
62a	I		100-200	0.06		0.63		0.57		9.97
62a	I	1.17	0-15	0.26	4.48	3.30	57.84	3.04	53.36	7.75
62a	I		15-30	0.18		2.26		2.09		7.76
62a	I		30-60	0.12		1.66		1.54		7.00
62a	I		60-100	0.06		0.79		0.73		7.51
62a	I		100-200	0.05		0.54		0.49		8.74
62a	I	1.17	0-15	0.11	1.88	1.12	19.71	1.02	17.83	9.55
62a	I		15-30	0.13		1.85		1.72		7.00
62a	I		30-60	0.16		2.83		2.67		5.66
62a	I		60-100	0.05		0.73		0.67		7.33
62a	I		100-200	0.03		0.45		0.41		7.80
62a	II	1.17	0-15	0.32	5.68	3.80	66.63	3.47	60.95	8.52
62a	II		15-30	0.19		1.88		1.70		9.93
62a	II		30-60	0.24		3.11		2.87		7.75
62a	II		60-100	0.12		1.29		1.17		9.39
62a	II		100-200	0.09		0.81		0.72		11.33
62a	II	1.17	0-15	0.22	3.86	5.92	103.86	5.70	100.00	3.72
62a	II		15-30	0.19		5.10		4.90		3.77
62a	II		30-60	0.15		3.29		3.15		4.44
62a	II		60-100	0.10		1.46		1.35		7.10
62a	II		100-200	0.05		0.56		0.52		8.30
62a	II	1.17	0-15	0.24	4.21	3.03	53.22	2.79	49.01	7.92
62a	II		15-30	0.24		3.08		2.84		7.81
62a	II		30-60	0.20		1.90		1.70		10.28
62a	II		60-100	0.17		1.38		1.21		12.20
62a	II		100-200	0.11		1.20		1.09		9.14
62a	II	1.17	0-15	0.35	6.13	4.50	79.04	4.15	72.92	7.75
62a	II		15-30	0.29		4.01		3.72		7.22
62a	II		30-60	0.30		3.18		2.88		9.47
62a	II		60-100	0.16		2.13		1.96		7.69
62a	II		100-200	0.07		0.68		0.61		9.94
62a	III	1.17	0-15	0.41	7.19	3.89	68.31	3.48	61.12	10.52
62a	III		15-30	0.43		4.24		3.81		10.18
62a	III		30-60	0.40		3.53		3.14		11.20
62a	III		60-100	0.30		2.20		1.90		13.50

62a	III		100-200	0.11		0.99		0.88		11.59
62a	III	1.17	0-15	0.30	5.31	4.46	78.35	4.16	73.04	6.77
62a	III		15-30	0.33		4.96		4.63		6.58
62a	III		30-60	0.30		3.79		3.49		7.88
62a	III		60-100	0.15		1.78		1.63		8.53
62a	III	1.17	0-15	0.48	8.43	5.06	88.81	4.58	80.38	9.49
62a	III		15-30	0.36		3.24		2.88		10.99
62a	III		30-60	0.34		3.18		2.84		10.71
62a	III		60-100	0.25		1.88		1.62		13.51
62a	III		100-200	0.27		3.03		2.75		8.96
62a	III	1.17	0-15	0.09	1.62	1.05	18.35	0.95	16.73	8.81
62a	III		15-30	0.18		1.37		1.20		12.90
62a	III		30-60	0.25		2.76		2.51		9.14
62a	III		60-100	0.28		2.95		2.67		9.39
62a	III		100-200	0.11		0.91		0.80		12.40
62a	IV	1.17	0-15	0.22	3.93	3.78	66.29	3.55	62.37	5.93
62a	IV		15-30	0.23		2.77		2.54		8.24
62a	IV		30-60	0.20		1.79		1.59		10.99
62a	IV		60-100	0.19		1.78		1.59		10.52
62a	IV		100-200	0.19		1.34		1.15		13.88
62a	IV	1.17	0-15	0.27	4.77	2.89	50.78	2.62	46.01	9.39
62a	IV		15-30	0.21		2.07		1.85		10.32
62a	IV		30-60	0.27		2.74		2.47		9.82
62a	IV		60-100	0.29		2.31		2.02		12.57
62a	IV		100-200	0.22		2.60		2.38		8.29
62a	IV	1.17	0-15	0.19	3.27	1.93	33.81	1.74	30.54	9.67
62a	IV		15-30	0.23		2.83		2.60		8.22
62a	IV		30-60	0.24		1.95		1.71		12.50
62a	IV		60-100	0.25		2.43		2.19		10.10
62a	IV		100-200	0.24		3.37		3.13		7.16
62a	IV	1.17	0-15	0.18	3.23	2.47	43.40	2.29	40.17	7.44
62a	IV		15-30	0.07		1.04		0.97		7.08
62a	IV		30-60	0.19		2.58		2.39		7.45
62a	IV		60-100	0.16		1.47		1.31		10.81
62a	IV		100-200	0.12		1.12		0.99		10.90
62a	V	1.17	0-15	0.21	3.72	2.94	51.68	2.73	47.95	7.21
62a	V		15-30	0.23		3.33		3.10		6.80
62a	V		30-60	0.21		2.23		2.02		9.32
62a	V		60-100	0.20		2.73		2.53		7.29
62a	V		100-200	0.15		1.75		1.61		8.30
62a	V	1.17	0-15	0.27	4.71	4.72	82.89	4.45	78.18	5.69
62a	V		15-30	0.23		3.73		3.51		6.08

62a	V		30-60	0.27		3.13		2.85		8.79
62a	V		60-100	0.20		2.12		1.92		9.53
62a	V		100-200	0.15		1.18		1.03		12.40
62a	V	1.17	0-15	0.19	3.27	2.77	48.60	2.58	45.33	6.74
62a	V		15-30	0.23		2.22		1.99		10.55
62a	V		30-60	0.14		1.60		1.45		9.06
62a	V		60-100	0.14		1.40		1.26		10.06
62a	V		100-200	0.15		1.40		1.25		10.50
62a	V	1.17	0-15	0.16	2.85	2.00	35.08	1.84	32.23	8.12
62a	V		15-30	0.18		2.44		2.25		7.47
62a	V		30-60	0.20		2.03		1.83		9.91
62a	V		60-100	0.20		2.24		2.04		9.09
62a	V		100-200	0.12		1.78		1.66		6.97
62a	VI	1.17	0-15	0.13	2.28	1.19	20.81	1.06	18.53	10.95
62a	VI		15-30	0.09		1.26		1.17		7.53
62a	VI		30-60	0.14		1.35		1.21		10.48
62a	VI		60-100	0.10		0.89		0.79		11.11
62a	VI		100-200	0.09		0.94		0.85		9.55
62a	VI	1.17	0-15	0.16	2.74	2.04	35.72	1.88	32.98	7.68
62a	VI		15-30	0.19		2.78		2.59		6.69
62a	VI		30-60	0.22		1.33		1.11		16.47
62a	VI		60-100	0.14		1.39		1.25		9.88
62a	VI		100-200	0.05		0.64		0.58		8.28
62a	VI	1.17	0-15	0.19	3.39	3.30	57.91	3.11	54.51	5.86
62a	VI		15-30	0.18		2.52		2.35		7.01
62a	VI		30-60	0.21		3.64		3.42		5.90
62a	VI		60-100	0.21		3.07		2.86		6.85
62a	VI		100-200	0.15		1.76		1.61		8.35
62a	VI	1.17	0-15	0.18	3.16	3.27	57.40	3.09	54.24	5.51
62a	VI		15-30	0.16		2.34		2.18		6.87
62a	VI		30-60	0.13		1.79		1.67		7.02
62a	VI		60-100	0.09		0.90		0.81		10.25
62a	VI		100-200	0.10		1.14		1.04		8.59
62a	VII	1.17	0-15	0.17	3.00	3.73	65.44	3.56	62.44	4.59
62a	VII		15-30	0.22		4.69		4.46		4.80
62a	VII		30-60	0.16		2.55		2.40		6.13
62a	VII		60-100	0.17		2.31		2.14		7.36
62a	VII		100-200	0.06		0.84		0.78		7.05
62a	VII	1.17	0-15	0.16	2.87	2.96	51.96	2.80	49.08	5.53
62a	VII		15-30	0.16		2.50		2.35		6.26
62a	VII		30-60	0.16		2.22		2.06		7.35
62a	VII		60-100	0.10		1.48		1.38		6.61

62a	VII		100-200	0.14		2.80		2.66		5.09
62a	VII	1.17	0-15	0.15	2.62	3.56	62.54	3.41	59.92	4.19
62a	VII		15-30	0.17		3.25		3.08		5.22
62a	VII		30-60	0.16		2.41		2.24		6.70
62a	VII		60-100	0.14		1.60		1.46		8.83
62a	VII		100-200	0.06		0.79		0.73		8.20
62a	VII	1.17	0-15	0.17	2.98	3.15	55.24	2.98	52.27	5.39
62a	VII		15-30	0.16		3.07		2.91		5.13
62a	VII		30-60	0.13		2.29		2.15		5.78
62a	VII		60-100	0.10		1.00		0.90		9.67
62a	VII		100-200	0.07		1.15		1.08		6.04
62b	I	1.17	0-15	0.18	3.18	3.41	59.86	3.23	56.68	5.31
62b	I		15-30	0.17		2.53		2.37		6.62
62b	I		30-60	0.10		1.52		1.42		6.69
62b	I		60-100	0.11		1.83		1.72		5.99
62b	I		100-200	0.07		0.73		0.65		10.20
62b	I	1.17	0-15	0.13	2.25	2.97	52.08	2.84	49.83	4.31
62b	I		15-30	0.05		0.78		0.73		6.44
62b	I		30-60	0.06		0.85		0.79		6.90
62b	I		60-100	0.05		0.60		0.55		8.85
62b	I		100-200	0.05		0.63		0.58		7.46
62b	I	1.17	0-15	0.22	3.89	4.13	72.51	3.91	68.62	5.36
62b	I		15-30	0.22		3.65		3.42		6.15
62b	I		30-60	0.20		2.28		2.08		8.63
62b	I		60-100	0.11		0.84		0.73		13.42
62b	I		100-200	0.08		0.63		0.54		13.38
62b	I	1.17	0-15	0.13	2.32	2.17	38.11	2.04	35.79	6.10
62b	I		15-30	0.12		1.59		1.47		7.47
62b	I		30-60	0.05		0.65		0.61		6.96
62b	I		60-100	0.04		0.46		0.42		8.32
62b	I		100-200	0.02		0.29		0.27		6.62
62b	II	1.17	0-15	0.21	3.76	2.79	48.93	2.57	45.16	7.69
62b	II		15-30	0.21		3.15		2.94		6.69
62b	II		30-60	0.19		2.95		2.76		6.58
62b	II		60-100	0.17		1.60		1.43		10.45
62b	II		100-200	0.07		0.66		0.59		11.12
62b	II	1.17	0-15	0.16	2.80	1.83	32.18	1.67	29.38	8.70
62b	II		15-30	0.17		2.57		2.41		6.43
62b	II		30-60	0.08		0.92		0.84		9.00
62b	II		60-100	0.10		0.87		0.77		11.51
62b	II		100-200	0.05		0.43		0.39		10.44
62b	II	1.17	0-15	0.20	3.56	3.42	60.00	3.22	56.45	5.93

62b	II		15-30	0.21		3.26		3.05		6.36
62b	II		30-60	0.20		3.20		3.01		6.13
62b	II		60-100	0.18		1.92		1.73		9.61
62b	II		100-200	0.10		1.19		1.09		8.73
62b	II	1.17	0-15	0.19	3.26	2.18	38.28	1.99	35.01	8.53
62b	II		15-30	0.24		3.03		2.79		8.01
62b	II		30-60	0.15		1.66		1.51		8.98
62b	II		60-100	0.13		1.07		0.95		11.75
62b	II		100-200	0.08		0.83		0.74		10.24
62b	III	1.17	0-15	0.26	4.52	4.04	70.91	3.78	66.39	6.38
62b	III		15-30	0.29		4.47		4.18		6.42
62b	III		30-60	0.24		2.90		2.65		8.43
62b	III		60-100	0.19		2.32		2.13		8.17
62b	III		100-200	0.16		1.62		1.47		9.57
62b	III	1.17	0-15	0.24	4.23	4.72	82.83	4.48	78.60	5.11
62b	III		15-30	0.22		4.07		3.85		5.47
62b	III		30-60	0.20		2.93		2.74		6.66
62b	III		60-100	0.83		2.59		1.76		32.05
62b	III		100-200	0.13		1.32		1.19		9.88
62b	III	1.17	0-15	0.23	4.05	4.16	73.07	3.93	69.03	5.54
62b	III		15-30	0.21		2.64		2.43		8.04
62b	III		30-60	0.15		1.71		1.55		9.00
62b	III		60-100	0.08		0.89		0.80		9.37
62b	III		100-200	0.08		0.66		0.57		12.70
62b	III	1.17	0-15	0.21	3.74	3.57	62.65	3.36	58.91	5.97
62b	III		15-30	0.22		3.89		3.68		5.62
62b	III		30-60	0.13		2.13		2.00		6.17
62b	III		60-200	0.17		1.83		1.66		9.30
62b	III		100-200	0.11		1.50		1.39		7.42
62b	IV	1.17	0-15	0.17	3.04	3.14	55.17	2.97	52.13	5.50
62b	IV		15-30	0.16		2.99		2.83		5.21
62b	IV		30-60	0.16		2.57		2.40		6.32
62b	IV		60-100	0.16		2.07		1.91		7.75
62b	IV		100-200	0.09		1.26		1.18		6.91
62b	IV	1.17	0-15	0.18	3.13	3.60	63.11	3.42	59.98	4.96
62b	IV		15-30	0.18		3.47		3.29		5.05
62b	IV		30-60	0.19		3.63		3.44		5.21
62b	IV		60-100	0.13		1.87		1.74		6.97
62b	IV		100-200	0.10		1.15		1.05		9.08
62b	IV	1.17	0-15	0.15	2.69	4.18	73.32	4.02	70.63	3.67
62b	IV		15-30	0.18		4.13		3.96		4.30
62b	IV		30-60	0.11		1.50		1.39		7.07

62b	IV		60-100	0.20		2.37		2.17		8.43
62b	IV		100-200	0.11		1.21		1.10		8.91
62b	IV	1.17	0-15	0.28	4.93	5.49	96.41	5.21	91.48	5.11
62b	IV		15-30	0.22		4.53		4.30		4.89
62b	IV		30-60	0.24		3.66		3.42		6.54
62b	IV		60-100	0.13		1.65		1.52		7.85
62b	IV		100-200	0.06		1.17		1.10		5.47
62b	V	1.17	0-15	0.18	3.10	4.30	75.47	4.12	72.36	4.11
62b	V		15-30	0.19		4.71		4.52		4.13
62b	V		30-60	0.15		2.59		2.44		5.91
62b	V		60-100	0.09		1.39		1.30		6.59
62b	V		100-200	0.07		1.17		1.10		5.90
62b	V	1.17	0-15	0.18	3.08	3.52	61.79	3.35	58.71	4.98
62b	V		15-30	0.13		2.59		2.46		5.19
62b	V		30-60	0.15		2.88		2.72		5.35
62b	V		60-100	0.11		1.70		1.59		6.39
62b	V		100-200	0.07		2.02		1.94		3.63
62b	V	1.17	0-15	0.14	2.50	3.49	61.25	3.35	58.75	4.08
62b	V		15-30	0.15		3.06		2.91		4.80
62b	V		30-60	0.22		3.39		3.17		6.42
62b	V		60-100	0.13		1.34		1.21		9.51
62b	V		100-200	0.11		2.03		1.92		5.32
62b	V	1.17	0-15	0.19	3.41	6.37	111.82	6.18	108.41	3.05
62b	V		15-30	0.21		3.35		3.14		6.24
62b	V		30-60	0.19		2.45		2.26		7.66
62b	V		60-100	0.15		1.65		1.50		8.92
62b	V		100-200	0.14		1.65		1.51		8.71
62b	VI	1.17	0-15	0.16	2.85	3.37	59.11	3.21	56.26	4.82
62b	VI		15-30	0.16		1.71		1.55		9.51
62b	VI		30-60	0.18		1.54		1.36		11.98
62b	VI		60-100	0.16		1.15		0.99		13.84
62b	VI		100-200	0.28		1.96		1.68		14.40
62b	VI	1.17	0-15	0.22	3.84	7.58	132.97	7.36	129.13	2.89
62b	VI		15-30	0.20		3.32		3.13		5.89
62b	VI		30-60	0.12		1.36		1.24		9.00
62b	VI		60-100	0.17		3.09		2.92		5.37
62b	VI		100-200	0.14		3.26		3.12		4.38
62b	VI	1.17	0-15	0.11	1.97	2.19	38.50	2.08	36.54	5.11
62b	VI		15-30	0.21		2.80		2.59		7.40
62b	VI		30-60	0.25		2.71		2.45		9.37
62b	VI		60-100	0.38		3.27		2.88		11.77
62b	VI		100-200	0.26		2.87		2.61		9.13

62b	VI	1.17	0-15	0.12	2.13	1.94	34.10	1.82	31.97	6.24
62b	VI		15-30	0.13		1.55		1.42		8.10
62b	VI		30-60	0.25		3.26		3.01		7.66
62b	VI		60-100	0.26		2.72		2.46		9.56
62b	VI		100-200	0.42		1.69		1.27		24.89
river	Nzoia			0.33		0.53		0.20		62.67
river	Yala			0.51		0.42		-0.10		123.21
river	Sondu			0.33		1.63		1.31		19.96
river	Simiyu			0.30		0.80		0.50		37.05
river	Kuja			0.34		1.30		0.95		26.45
river	Awach			0.25		0.84		0.59		30.01
river	Nile			0.60		5.52		4.92		10.86
river	Grumeti			0.38		1.80		1.42		21.18
river	Kagera			1.64		0.26		-1.38		629.18
river	Kibuon			1.21		31.40		30.19		3.85
Lake victoria	Asembo bay			0.09		2.96		2.87		2.31

Table 3.S16. Data for chapter 3 tables 3.2, 3.3, and 3.4 and figures 3.5, 3.6, and 3.7.

Catchment	Date	BC (mg/L)	Ctot (mg/L)	BC % Ctot	BC DOC (mg/L)	Ctot DOC (mg/L)	BC % Ctot
Fa	18-Jan-12	#DIV/0!	#DIV/0!	#DIV/0!	0.08	1.82	4.48
Fa	5-Feb-12	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.00	#DIV/0!
Fa	18-Feb-12	0.00	0.03	4.33	0.00	0.03	4.53
Fa	1-Mar-12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	18-Mar-12	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.05	3.29
Fa	4-Apr-12	0.00	0.00	#DIV/0!	0.00	0.09	4.08
Fa	20-Apr-12	0.00	0.03	2.77	0.00	0.03	4.58
Fa	7-May-12	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.07	3.25
Fa	12-May-12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	4-Jun-12	0.00	0.03	4.52	0.00	0.04	3.70
Fa	19-Jun-12	0.00	0.02	3.07	0.00	0.03	4.38
Fa	4-Jul-12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	18-Jul-12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	4-Aug-12	0.00	0.08	2.93	0.00	0.04	3.21
Fa	17-Aug-12	0.00	0.04	2.88	0.01	0.10	5.45
Fa	5-Sep-12	0.00	0.04	3.83	0.00	0.05	3.74
Fa	17-Sep-12	0.00	0.02	5.46	0.00	0.04	3.97
Fa	5-Oct-12	0.00	0.00	#DIV/0!	0.00	0.05	2.58
Fa	18-Oct-12	0.00	0.00	#DIV/0!	0.00	0.00	#DIV/0!

Fa	5-Nov-12	0.00	0.05	3.88	0.00	0.04	4.31
Fa	17-Nov-12	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.09	4.23
Fa	4-Dec-12	0.00	0.02	4.91	0.00	0.04	4.41
Fa	18-Dec-12	0.00	0.01	4.16	0.00	0.03	4.67
Fa	5-Jan-13	0.04	1.51	2.51	0.05	1.75	3.11
Fa	13-Jan-13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	3-Feb-13	0.00	0.03	4.95	#DIV/0!	#DIV/0!	#DIV/0!
Fa	16-Feb-13	0.00	0.02	3.42	0.00	0.03	3.59
Fa	5-Mar-13	0.00	0.05	1.90	0.00	0.03	3.35
Fa	20-Mar-13	0.00	0.03	4.25	0.00	0.03	2.84
Fa	4-Apr-13	0.00	0.05	2.89	#DIV/0!	#DIV/0!	#DIV/0!
Fa	18-Apr-13	0.00	0.04	2.86	0.00	0.05	2.57
Fa	3-May-13	0.00	0.06	2.78	0.00	0.04	4.99
Fa	13-May-13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	13-Jun-13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fa	20-Jun-13	0.00	0.00	#DIV/0!	0.00	0.08	4.10
Fa	4-Jul-13	0.00	0.06	3.26	#DIV/0!	#DIV/0!	#DIV/0!
Fa	18-Jul-13	0.00	0.00	#DIV/0!	0.00	0.00	#DIV/0!
Fa	2-Aug-13	0.00	0.07	4.59	0.00	0.05	4.52
Fa	16-Aug-13	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.06	3.50
Fa	3-Sep-13	0.00	0.03	6.05	0.00	0.12	2.02
Fa	17-Sep-13	0.00	0.02	3.45	0.00	0.05	2.35
FB	18-Jan-12	0.00	0.13	2.55	0.00	0.07	4.02
FB	5-Feb-12	0.00	0.06	2.83	0.00	0.05	2.83
FB	18-Feb-12	0.00	0.06	4.31	0.00	0.07	3.88
FB	1-Mar-12	0.00	0.16	2.18	0.00	0.06	4.02
FB	18-Mar-12	0.00	0.06	4.88	0.00	0.07	3.99
FB	4-Apr-12	0.00	0.16	1.66			
FB	20-Apr-12	0.00	0.04	6.04	0.00	0.04	3.89
FB	7-May-12	0.00	0.08	4.10	0.00	0.02	2.82
FB	12-May-14						
FB	4-Jun-12	0.00	0.08	1.81	0.00	0.04	3.82
FB	19-Jun-12	0.00	0.07	2.63	0.00	0.04	2.53
FB	4-Jul-12	0.00	0.03	5.04	0.00	0.04	4.70
FB	18-Jul-12	0.00	0.04	3.84	0.00	0.06	2.55
FB	4-Aug-12	0.00	0.05	2.74	0.00	0.04	3.26
FB	17-Aug-12	0.00	0.06	2.27	0.00	0.05	4.33
FB	5-Sep-12	0.00	0.05	1.71	0.00	0.10	3.52
FB	17-Sep-12				0.00	0.04	4.34
FB	5-Oct-12				0.00	0.03	2.70
FB	18-Oct-12	0.02	0.60	3.89	0.00	0.04	2.22
FB	5-Nov-12	0.00	0.04	3.75	0.00	0.04	4.96

FB	17-Nov-12				0.00	0.05	2.34
FB	4-Dec-12	0.00	0.05	3.08	0.00	0.06	3.11
FB	18-Dec-12	0.00	0.04	3.40	0.00	0.06	3.52
FB	5-Jan-13						
FB	13-Jan-13						
FB	3-Feb-13	0.00	0.06	3.04	0.00	0.07	2.91
FB	16-Feb-13	0.00	0.10	2.69	0.00	0.08	2.46
FB	5-Mar-13	0.00	0.07	2.57	0.00	0.07	4.45
FB	20-Mar-13	0.00	0.07	3.72	0.00	0.03	2.91
FB	4-Apr-13				0.00	0.03	2.38
FB	18-Apr-13	0.00	0.08	1.89	0.00	0.06	2.35
FB	3-May-13	0.00	0.06	2.92	0.00	0.05	3.70
FB	13-May-13						
FB	13-Jun-13						
FB	20-Jun-13	0.00	0.07	2.13	0.00	0.06	2.36
FB	4-Jul-13				0.00	0.04	4.39
FB	18-Jul-13	0.00	0.04	5.03	0.00	0.03	1.84
FB	2-Aug-13	0.00	0.04	3.06	0.00	0.07	2.30
FB	16-Aug-13	0.00	0.06	2.91	0.00	0.05	5.35
FB	3-Sep-13	0.00	0.04	2.81	0.00	0.05	1.98
FB	17-Sep-13						
10a	18-Jan-12	0.00	0.06	2.42	0.00	0.17	1.33
10a	5-Feb-12	0.25	6.55	3.86	0.00	0.04	1.98
10a	18-Feb-12						
10a	1-Mar-12	0.00	0.07	1.90	0.00	0.05	3.30
10a	18-Mar-12	38.95	1121.29	3.47	0.00	0.04	3.66
10a	4-Apr-12						
10a	20-Apr-12	0.00	0.04	4.24			
10a	7-May-12	13.21	974.29	1.36	0.00	0.03	4.51
10a	12-May-14						
10a	4-Jun-12	0.00	0.05	2.84			
10a	19-Jun-12	0.00	0.05	2.95	0.00	0.04	4.32
10a	4-Jul-12	0.00	0.07	2.23	0.00	0.04	4.67
10a	18-Jul-12	0.00	0.06	2.11	0.00	0.06	1.42
10a	4-Aug-12	0.00	0.08	1.56	0.00	0.04	4.23
10a	17-Aug-12	0.00	0.04	4.18	0.00	0.04	3.70
10a	5-Sep-12	0.00	0.06	2.05	0.00	0.03	2.37
10a	17-Sep-12	0.00	0.04	1.82	0.00	0.04	2.44
10a	5-Oct-12				0.00	0.02	4.07
10a	18-Oct-12	0.00	0.07	4.06	0.00	0.08	2.15
10a	5-Nov-12	0.00	0.02	6.27	0.00	0.04	4.21
10a	17-Nov-12	0.12	4.98	2.46	0.00	0.06	2.26

10a	4-Dec-12	0.00	0.03	2.95	0.00	0.04	5.10
10a	18-Dec-12						
10a	5-Jan-13	0.00	0.07	3.13	0.00	0.06	2.54
10a	13-Jan-13						
10a	3-Feb-13	0.00	0.05	3.75	0.00	0.08	4.72
10a	16-Feb-13	0.00	0.08	2.04	0.00	0.07	5.07
10a	5-Mar-13	0.00	0.07	2.12	0.00	0.04	2.81
10a	20-Mar-13				0.00	0.04	3.94
10a	4-Apr-13	0.00	0.04	1.47			
10a	18-Apr-13	0.00	0.04	4.74	0.00	0.04	4.09
10a	3-May-13	0.00	0.09	3.08	0.00	0.05	4.34
10a	13-May-13	0.03	1.15	2.96			
10a	13-Jun-13						
10a	20-Jun-13				0.00	0.03	2.54
10a	4-Jul-13	0.00	0.04	2.70	0.00	0.03	4.24
10a	18-Jul-13	0.00	0.04	2.85	0.00	0.09	1.74
10a	2-Aug-13	0.00	0.06	1.80	0.00	0.05	6.26
10a	16-Aug-13						
10a	3-Sep-13	0.00	0.10	1.96	0.00	0.03	4.58
10a	17-Sep-13	0.00	0.04	3.31	0.00	0.04	3.98
10b	18-Jan-12	0.00	0.05	3.02			
10b	5-Feb-12	0.00	0.04	5.49	0.00	0.03	5.58
10b	18-Feb-12	0.00	0.03	6.56			
10b	1-Mar-12						
10b	18-Mar-12						
10b	4-Apr-12	0.00	0.05	2.36	0.00	0.08	4.21
10b	20-Apr-12	0.00	0.06	2.68			
10b	7-May-12	0.00	0.05	5.37	0.00	0.04	4.65
10b	12-May-14						
10b	4-Jun-12	0.00	0.04	4.77	0.00	0.07	1.48
10b	19-Jun-12	0.00	0.05	2.24	0.00	0.04	3.26
10b	4-Jul-12	0.00	0.03	5.84	0.00	0.03	5.04
10b	18-Jul-12	0.00	0.03	3.55	0.00	0.05	2.58
10b	4-Aug-12	0.00	0.03	3.06	0.00	0.03	4.38
10b	17-Aug-12	0.00	0.03	4.39	0.00	0.03	4.56
10b	5-Sep-12	0.04	1.71	2.22	0.00	0.05	3.39
10b	17-Sep-12	0.00	0.07	2.89	0.00	0.04	3.74
10b	5-Oct-12	0.00	0.03	4.69	0.00	0.03	5.41
10b	18-Oct-12	0.00	0.03	4.48	0.00	0.04	5.07
10b	5-Nov-12	0.00	0.04	4.63	0.00	0.04	3.49
10b	17-Nov-12	0.00	0.04	3.49	0.00	0.03	4.78
10b	4-Dec-12				0.00	0.03	4.41

10b	18-Dec-12	0.00	0.05	1.94	0.00	0.03	3.54
10b	5-Jan-13	0.00	0.02	5.02			
10b	13-Jan-13						
10b	3-Feb-13	0.00	0.03	6.81	0.00	0.04	3.36
10b	16-Feb-13	0.00	0.06	3.10			
10b	5-Mar-13	0.00	0.05	2.14			
10b	20-Mar-13						
10b	4-Apr-13	0.00	0.07	2.23	0.00	0.04	3.30
10b	18-Apr-13	0.00	0.08	3.44	0.00	0.03	4.87
10b	3-May-13	0.11	2.42	4.65	0.00	0.03	1.39
10b	13-May-13						
10b	18-Jun-12						
10b	20-Jun-13	0.00	0.06	3.37			
10b	4-Jul-13				0.00	0.06	3.02
10b	18-Jul-13	0.00	0.06	2.11	0.02	0.38	4.27
10b	2-Aug-13	0.00	0.05	5.26	0.00	0.10	2.26
10b	16-Aug-13	0.05	1.64	3.07	0.00	0.04	3.53
10b	3-Sep-13	0.00	0.05	3.15	0.01	0.15	3.62
10b	17-Sep-13	0.00	0.04	3.76	0.00	0.06	2.56
16a	18-Jan-12				0.00	0.06	3.01
16a	5-Feb-12	0.00	0.09	1.64	0.00	0.05	3.48
16a	18-Feb-12	0.00	0.11	1.32	0.00	0.11	1.50
16a	1-Mar-12	0.00	0.08	2.75	0.00	0.04	2.91
16a	18-Mar-12	0.00	0.05	2.63	0.00	0.06	1.92
16a	4-Apr-12				0.00	0.06	1.74
16a	20-Apr-12				0.00	0.09	1.48
16a	7-May-12	0.00	0.13	2.34	0.00	0.09	4.20
16a	12-May-14						
16a	4-Jun-12	0.00	0.10	1.58	0.00	0.09	1.82
16a	19-Jun-12	0.00	0.11	2.73			
16a	4-Jul-12	0.00	0.05	2.30	0.00	0.08	2.37
16a	18-Jul-12	0.00	0.10	2.39			
16a	4-Aug-12	0.00	0.13	3.48	0.00	0.09	1.83
16a	17-Aug-12	0.00	0.08	2.32	0.01	0.27	4.17
16a	5-Sep-12	0.00	0.09	1.97	0.00	0.07	1.85
16a	17-Sep-12	0.00	0.10	3.12	0.00	0.05	1.93
16a	5-Oct-12	0.00	0.08	1.75	0.00	0.07	2.49
16a	18-Oct-12	0.00	0.06	2.43	0.00	0.05	4.21
16a	5-Nov-12	0.00	0.05	1.36	0.00	0.09	1.90
16a	17-Nov-12	0.00	0.07	2.74	0.00	0.04	2.12
16a	4-Dec-12	0.00	0.06	2.12	0.00	0.07	3.03
16a	18-Dec-12	0.00	0.03	3.96			

16a	5-Jan-13	0.00	0.05	3.34	0.00	0.00	2.38
16a	13-Jan-13						
16a	3-Feb-13						
16a	16-Feb-13	0.00	0.09	1.99	0.00	0.06	1.52
16a	5-Mar-13						
16a	20-Mar-13	0.02	1.10	2.25			
16a	4-Apr-13				0.00	0.06	4.11
16a	18-Apr-13						
16a	3-May-13	0.00	0.08	1.67	0.00	0.01	2.31
16a	13-May-13						
16a	13-Jun-13						
16a	20-Jun-13						
16a	4-Jul-13	0.00	0.05	2.74	0.00	0.05	1.96
16a	18-Jul-13	0.00	0.04	1.87	0.00	0.02	2.26
16a	2-Aug-13	0.00	0.06	2.13	0.00	0.04	1.81
16a	16-Aug-13	0.00	0.06	3.39	0.00	0.08	2.68
16a	3-Sep-13	0.00	0.06	1.39	0.00	0.07	1.87
16a	17-Sep-13	0.00	0.07	2.45	0.00	0.04	1.46
16b	18-Jan-12	0.00	0.08	1.63	0.00	0.02	1.57
16b	5-Feb-12	0.00	0.10	1.65	0.00	0.11	2.77
16b	18-Feb-12	0.09	7.59	1.21	0.01	0.20	2.91
16b	1-Mar-12	0.00	0.14	2.84	0.00	0.12	2.02
16b	18-Mar-12	0.00	0.14	1.52	0.00	0.29	1.35
16b	4-Apr-12	0.01	0.18	2.82	0.00	0.08	2.11
16b	20-Apr-12				0.00	0.22	1.73
16b	7-May-12	0.00	0.12	1.88	0.00	0.08	2.92
16b	12-May-14						
16b	19-Jun-12	0.00	0.11	1.33	0.00	0.07	3.54
16b	4-Jun-12	0.00	0.07	2.19			
16b	4-Jul-12	0.00	0.18	1.18	0.00	0.09	2.81
16b	18-Jul-12	0.00	0.08	1.86	0.00	0.06	2.17
16b	4-Aug-12	0.00	0.06	1.71			
16b	17-Aug-12	0.00	0.09	1.44	0.00	0.06	1.39
16b	5-Sep-12	0.00	0.07	2.14	0.00	0.07	3.58
16b	17-Sep-12				0.00	0.05	2.05
16b	5-Oct-12	0.00	0.09	2.44	0.00	0.15	2.13
16b	18-Oct-12	0.00	0.07	2.14	0.00	0.06	1.92
16b	5-Nov-12	0.00	0.07	3.49	0.00	0.07	2.11
16b	17-Nov-12	0.00	0.11	3.22	0.00	0.04	2.23
16b	4-Dec-12	0.00	0.06	1.67	0.37	11.22	3.28
16b	18-Dec-12				0.00	0.08	3.46
16b	5-Jan-13	0.00	0.10	1.11	0.00	0.06	3.29

16b	13-Jan-13						
16b	3-Feb-13	0.00	0.11	1.91	0.00	0.09	2.08
16b	16-Feb-13	0.00	0.09	3.17	0.00	0.08	1.94
16b	5-Mar-13	0.00	0.10	1.96	0.00	0.07	3.89
16b	20-Mar-13	0.00	0.08	2.83	0.00	0.04	3.00
16b	4-Apr-13				0.00	0.09	2.86
16b	18-Apr-13	0.00	0.09	1.75			
16b	3-May-13	0.00	0.07	2.11	0.00	0.08	3.45
16b	13-May-13						
16b	13-Jun-14						
16b	20-Jun-13	0.00	0.16	2.93	0.00	0.07	3.45
16b	4-Jul-13	0.00	0.09	1.84	0.00	0.10	2.98
16b	18-Jul-13	0.00	0.08	3.10	0.00	0.09	3.69
16b	9-Aug-13						
16b	2-Aug-13	0.00	0.11	2.35	0.00	0.09	2.07
16b	3-Sep-13	0.00	0.08	4.29	0.00	0.10	1.94
16b	17-Sep-13	0.00	0.05	2.92	0.00	0.08	2.67
62a	18-Jan-12	0.00	0.14	2.48	0.00	0.09	1.92
62a	5-Feb-12	0.00	0.06	2.51	0.00	0.07	3.38
62a	18-Feb-12	0.00	0.12	2.67	0.04	1.87	1.92
62a	1-Mar-12	0.02	0.52	3.29	0.05	1.68	2.71
62a							
62a	4-Apr-12	0.00	0.08	2.41	0.00	0.07	2.49
62a	20-Apr-12	0.00	0.08	3.39	0.00	0.11	2.47
62a	7-May-12	0.00	0.12	1.35	0.00	0.06	1.47
62a	12-May-14						
62a	4-Jun-12	0.00	0.07	1.41	0.00	0.06	2.24
62a	19-Jun-12	0.00	0.08	1.71	0.00	0.07	2.22
62a	4-Jul-12				0.00	0.02	2.32
62a	18-Jul-12	0.00	0.04	4.87	0.00	0.07	2.90
62a	4-Aug-12				0.00	0.08	2.36
62a	17-Aug-12	0.00	0.08	3.09	0.00	0.07	4.19
62a	5-Sep-12	0.00	0.07	4.10	0.00	0.10	2.57
62a	17-Sep-12	0.02	0.91	1.93	0.00	0.03	2.79
62a	5-Oct-12	0.00	0.09	2.49	0.00	0.05	4.36
62a	18-Oct-12	0.00	0.09	2.12	0.00	0.04	2.54
62a	5-Nov-12	0.00	0.08	2.66	0.00	0.08	2.84
62a	17-Nov-12	0.00	0.12	1.41	0.00	0.04	3.13
62a	4-Dec-12	0.00	0.09	1.88	0.00	0.08	1.40
62a	18-Dec-12				0.00	0.07	1.68
62a	5-Jan-13	0.00	0.09	2.18	0.00	0.08	2.85
62a	13-Jan-13						

62a	3-Feb-13	0.00	0.11	1.85	0.00	0.06	2.60
62a	16-Feb-13	0.00	0.09	2.96	0.00	0.06	5.88
62a	5-Mar-13	0.00	0.10	1.40	0.00	0.04	4.09
62a	20-Mar-13	0.00	0.11	1.87	0.00	0.05	3.47
62a	4-Apr-13	0.00	0.06	2.66	0.00	0.13	2.60
62a	18-Apr-13	0.00	0.07	2.96	0.00	0.08	1.80
62a	3-May-13				0.00	0.05	4.47
62a	13-May-14						
62a	13-Jun-14						
62a	20-Jun-13	0.01	0.36	1.65	0.00	0.06	2.56
62a	4-Jul-13				0.00	0.07	4.03
62a	18-Jul-13	0.00	0.07	2.55	0.01	0.14	4.29
62a	2-Aug-13	0.02	0.74	2.63			
62a	16-Aug-13	0.00	0.09	1.84	0.00	0.10	2.67
62a	3-Sep-13	0.00	0.03	5.26	0.00	0.06	2.94
62a	17-Sep-13	0.00	0.05	2.73	0.00	0.05	1.86
62b	18-Jan-12	0.00	0.15	1.67	0.00	0.15	1.30
62b	5-Feb-12	0.00	0.15	2.24			
62b	18-Feb-14	0.00	0.13	2.75	0.00	0.11	2.57
62b	1-Mar-14	0.00	0.13	2.71	0.00	0.13	2.49
62b	18-Mar-12						
62b	4-Apr-12	0.00	0.15	2.26	0.00	0.11	2.61
62b	20-Apr-12	0.00	0.15	2.61	0.00	0.19	2.05
62b	7-May-12	0.00	0.16	1.90	0.00	0.10	4.04
62b	12-May-14						
62b	4-Jun-12	0.00	0.16	1.91	0.00	0.10	2.41
62b	19-Jun-12	0.00	0.14	2.14	0.00	0.10	4.15
62b	4-Jul-12	0.00	0.07	2.82	0.00	0.11	2.18
62b	18-Jul-12	0.01	0.22	2.32	0.00	0.24	1.48
62b	4-Aug-12	0.01	0.26	2.41			
62b	17-Aug-12	0.00	0.12	1.67	0.00	0.11	2.91
62b	5-Sep-12	0.00	0.27	1.70			
62b	17-Sep-12	0.00	0.15	1.63	0.00	0.08	1.75
62b	18-Oct-12	0.00	0.14	2.57	0.00	0.11	3.72
62b	5-Oct-12	0.00	0.05	4.42	0.00	0.10	3.56
62b	5-Nov-12	0.00	0.11	3.35	0.00	0.09	2.93
62b	17-Nov-12	0.00	0.11	3.40			
62b	4-Dec-12						
62b	18-Dec-12	0.00	0.12	2.46	0.00	0.09	3.31
62b	5-Jan-13	0.00	0.10	2.84			
62b	13-Jan-13						
62b	3-Feb-13	0.00	0.14	1.58	0.00	0.12	2.17

62b	16-Feb-13	0.00	0.15	1.98	0.00	0.08	2.96
62b	5-Mar-13						
62b	20-Mar-13	0.00	0.16	1.88			
62b	4-Apr-13	0.00	0.10	3.15	0.00	0.10	2.98
62b	18-Apr-13	0.00	0.13	2.13	0.00	0.10	1.96
62b	3-May-13	0.00	0.12	2.28	0.00	0.11	2.41
62b	13-May-14						
62b	13-Jun-14						
62b	20-Jun-13	0.00	0.14	2.27	0.00	0.11	3.94
62b	4-Jul-13	0.00	0.10	2.77	0.00		
62b	18-Jul-13	0.00	0.12	1.93	0.11		
62b	2-Aug-13	0.00	0.09	2.74	0.00	0.10	2.11
62b	16-Aug-13	0.00	0.09	4.58	0.00	0.10	3.01
62b	3-Sep-13	0.00	0.07	3.76	0.00	0.11	3.03
62b	17-Sep-13	0.00	0.10	2.87			
Rifer Magu		0.31	7.62	4.02			
River Yala		0.48	13.54	3.52			
River Nile		0.09	8.08	1.12			
Lake Victoria Asembo Bay		0.22	7.16	3.04			
River Grumeti		1.04	12.77	8.18			
River Nzoia		0.65	13.98	4.65			
River Awach		0.53	10.33	5.18			
River Kibuon		0.72	10.48	6.84			
River Sondu Miriu		0.33	7.76	4.22			
River Nyando		1.57	20.26	7.73			
River Kagera		0.38	23.92	1.57			
River Simiyu		0.41	11.76	3.51			
River Kuja		2.07	23.61	8.76			
River Mara		0.23	9.67	2.34			

Table 3.S17. Data for chapter 3 tables 3.3 and 3.4 and figure 3.6

Watershed	Date	Q (mm3/day)	Q (mm/day*ha)
Fa	4-Aug-12	68285.52213	0.533480642
Fa	17-Aug-12	74526.94187	0.582241733
Fa	5-Sep-12	70675.17594	0.552149812
Fa	17-Sep-12	63307.60415	0.494590657
Fa	5-Oct-12	71027.58954	0.554903043
Fa	18-Oct-12	110309.5432	0.861793306
Fa	5-Nov-12	61961.29066	0.484072583

Fa	17-Nov-12	65737.64837	0.513575378
Fa	4-Dec-12	70882.88761	0.553772559
Fa	18-Dec-12	74388.73996	1.312966446
Fa	5-Jan-13	126367.7737	0.987248232
Fa	13-Jan-13	66191.25606	0.517119188
Fa	3-Feb-13	60402.89	1.06611522
Fa	16-Feb-13	66062.91813	0.516116548
Fa	5-Mar-13	64197.26536	0.501541136
Fa	20-Mar-13	81926.46238	0.640050487
Fa	4-Apr-13	79355.38582	0.619963952
Fa	18-Apr-13	75022.46331	0.586112995
Fa	3-May-13	78288.72577	0.61163067
Fa	13-May-13	82645.60219	0.645668767
Fa	13-Jun-13	78202.17107	0.610954462
Fa	20-Jun-13	72447.32666	0.56599474
Fa	4-Jul-13	65301.17002	0.510165391
Fa	18-Jul-13	70051.10257	0.547274239
Fa	2-Aug-13	81904.69729	0.639880448
Fa	16-Aug-13	91283.82798	0.713154906
Fa	3-Sep-13	89853.06664	0.701977083
10a	17-Aug-12	80294.50972	1.28800946
10a	5-Sep-12	81191.69653	1.302401292
10a	17-Sep-12	74704.73682	1.198343549
10a	5-Oct-12	71116.39159	1.140782669
10a	18-Oct-12	37859.17228	0.607301448
10a	5-Nov-12	113181.3826	1.81554993
10a	17-Nov-12	58865.35342	0.944262968
10a	4-Dec-12	65345.70586	1.048214723
10a	18-Dec-12	63526.1537	1.019027169
10a	5-Jan-13	99869.0805	1.602006424
10a	13-Jan-13	57231.57228	0.918055378
10a	3-Feb-13	56064.91831	0.899341006
10a	16-Feb-13	56850.36472	0.911940403
10a	5-Mar-13	56522.54052	0.906681754
10a	20-Mar-13	72853.46116	1.168647115
10a	4-Apr-13	66477.9906	1.066377777
10a	18-Apr-13	61067.7327	0.979591477
10a	3-May-13	60015.14392	0.962706832
10a	13-May-13	81899.016	1.31374745
10a	13-Jun-13	73530.69058	1.297821815
10a	20-Jun-13	73926.42941	1.185858669
10a	4-Jul-13	72045.68942	1.155689596

10a	18-Jul-13	74027.86983	1.187485881
10a	2-Aug-13	7111.604649	1.427045197
10a	16-Aug-13	76102.90687	1.220771686
10a	3-Sep-13	72015.85309	1.15521099
10b	17-Aug-12	78331.42685	1.382555145
10b	5-Sep-12	77711.37716	1.371611225
10b	17-Sep-12	61070.44586	1.077897627
10b	5-Oct-12	63833.6132	1.126667723
10b	18-Oct-12	80396.9543	1.350275267
10b	5-Nov-12	83171.82257	1.467988467
10b	17-Nov-12	61348.14561	1.082799047
10b	4-Dec-12	64084.6645	1.131098796
10b	18-Dec-12	350127.7333	1.290886779
10b	5-Jan-13	112920.6637	1.993057588
10b	13-Jan-13	63668.51185	1.123753673
10b	3-Feb-13	62868.93372	1.109641063
10b	16-Feb-13	62665.5401	1.106051152
10b	5-Mar-13	65331.16129	1.153099551
10b	20-Mar-13	72853.46116	1.285868669
10b	4-Apr-13	70415.51735	1.24283879
10b	18-Apr-13	67301.56296	1.187877278
10b	3-May-13	71595.8424	1.26367161
10b	13-May-13	83859.3418	1.480123229
10b	18-Jun-12	74679.03146	1.318090112
10b	20-Jun-13	72192.56235	1.274203759
10b	4-Jul-13	65465.81415	1.155476184
10b	18-Jul-13	70712.01284	1.248071957
10b	2-Aug-13	88961.99756	1.570185459
10b	16-Aug-13	79085.46901	1.395864042
10b	3-Sep-13	88432.25658	1.560835494
16a	4-Aug-12	77745.35947	0.983222373
16a	17-Aug-12	74405.16133	0.940979883
16a	5-Sep-12	84713.06792	1.071340903
16a	17-Sep-12	64394.47672	0.814377741
16a	5-Oct-12	67561.61206	0.854431557
16a	18-Oct-12	72578.49521	0.917878582
16a	5-Nov-12	90498.3901	1.144506148
16a	17-Nov-12	64045.94018	0.809969903
16a	4-Dec-12	65398.61014	0.827076717
16a	18-Dec-12	69700.0838	0.881476171
16a	5-Jan-13	107655.8824	1.361491836
16a	13-Jan-13	64862.79654	0.820300442

16a	3-Feb-13	65021.95736	0.822313301
16a	16-Feb-13	84563.56437	1.069450177
16a	5-Mar-13	64257.28407	0.812642706
16a	20-Mar-13	78423.06327	0.991793091
16a	4-Apr-13	77141.21654	0.975581957
16a	18-Apr-13	65381.50781	0.826860429
16a	3-May-13	77001.17717	0.973810921
16a	13-May-13	90417.41138	1.143482034
16a	13-Jun-13	82401.5603	1.042107956
16a	20-Jun-13	73461.59624	0.929046897
16a	4-Jul-13	64707.56008	0.818337213
16a	18-Jul-13	35680198.33	451.2368263
16a	2-Aug-13	77129.65898	0.975435792
16a	16-Aug-13	81279.69373	1.027920044
16a	3-Sep-13	108303.6553	1.369684026
16b	4-Aug-12	110674.0183	7.64428915
16b	17-Aug-12	116454.564	8.043553252
16b	5-Sep-12	111817.2744	7.723254209
16b	17-Sep-12	102546.5518	7.082922491
16b	5-Oct-12	98851.46887	6.827701953
16b	18-Oct-12	106563.135	7.360349151
16b	5-Nov-12	127241.2514	8.788593132
16b	17-Nov-12	92038.78156	6.357147504
16b	4-Dec-12	100741.3782	6.958238584
16b	18-Dec-12	105976.0681	7.319800253
16b	5-Jan-13	170497.1051	11.77628851
16b	13-Jan-14	100076.7777	6.912334415
16b	3-Feb-13	97284.74552	6.719487879
16b	16-Feb-13	100254.3621	6.924600225
16b	5-Mar-13	98325.42903	6.791368216
16b	20-Mar-13	121417.8784	8.386370936
16b	4-Apr-13	123507.3011	8.530688013
16b	18-Apr-13	123870.2787	8.555758996
16b	3-May-13	112677.7828	7.782689789
16b	13-May-13	86614.30377	5.982477122
16b	13-Jun-14	118606.6924	8.19220144
16b	20-Jun-13	115641.2736	7.987379027
16b	4-Jul-13	104092.5337	7.189703943
16b	18-Jul-13	140169.2634	9.681534981
16b	9-Aug-13	105262.357	7.270504004
16b	17-Aug-13	90968.82855	6.283245514
16b	3-Sep-13	152055.6935	10.50253443

62a	4-Aug-12	64234.77063	1.398079674
62a	17-Aug-12	68689.98805	1.495048167
62a	5-Sep-12	86604.13194	1.884952268
62a	17-Sep-12	63266.62839	1.377007909
62a	5-Oct-12	78385.3873	1.706070025
62a	18-Oct-12	97998.63466	2.132955374
62a	5-Nov-12	111541.0948	2.427709104
62a	17-Nov-12	68567.25285	1.492376817
62a	4-Dec-12	56379.34245	1.22710507
62a	18-Dec-12	74962.74834	1.631575761
62a	5-Jan-13	125288.5704	2.726925028
62a	13-Jan-14	76725.8122	1.669949117
62a	3-Feb-13	81846.84778	1.781409245
62a	16-Feb-13	68750.52524	1.496365769
62a	5-Mar-13	68922.58834	1.500110749
62a	20-Mar-13	72304.22084	1.573712501
62a	4-Apr-13	99703.53707	2.170062838
62a	18-Apr-13	106846.335	2.325526933
62a	3-May-13	121453.7532	2.643459641
62a	13-May-14	62644.39354	1.363464872
62a	13-Jun-14	88232.5245	1.920394483
62a	20-Jun-13	68664.30025	1.494489068
62a	4-Jul-13	58978.16232	1.283668785
62a	18-Jul-13	73036.06337	1.589641166
62a	2-Aug-13	7245.802575	0.157706009
62a	16-Aug-13	73531.63778	1.600427419
62a	3-Sep-13	105276.6475	2.291362443
62b	4-Aug-12	88255.00011	2.393485751
62b	17-Aug-12	99143.61126	2.688786138
62b	5-Sep-12	126857.2208	3.440382415
62b	17-Sep-12	98691.62652	2.67652826
62b	5-Oct-12	73837.69462	2.002486769
62b	18-Oct-12	76973.8388	2.087539359
62b	5-Nov-12	93872.88015	2.545843304
62b	17-Nov-12	84818.57231	2.300289434
62b	4-Dec-12	77077.697	2.090356006
62b	18-Dec-12	81179.69456	2.201602651
62b	5-Jan-13	152845.4892	1.932991314
62b	13-Jan-14	77576.3105	0.981084461
62b	3-Feb-13	78643.62133	0.994582423
62b	16-Feb-13	78843.95593	0.997115995
62b	5-Mar-13	78820.46147	0.996818867

62b	20-Mar-13	95925.72042	1.213143975
62b	4-Apr-13	106335.7175	1.344796104
62b	18-Apr-13	82487.10945	1.043189871
62b	3-May-13	79821.41833	1.00947767
62b	13-May-14	99433.11577	2.696637533
62b	13-Jun-14	96819.43996	1.22444658
62b	20-Jun-13	84700.10735	1.071176995
62b	4-Jul-13	85490.78192	1.08117642
62b	18-Jul-13	69801.67725	0.882760993
62b	2-Aug-13	99424.31872	1.257389705
62b	16-Aug-13	94378.26744	1.193573799
62b	3-Sep-13	106943.5943	1.35248374

Table 3.S18. Data from chapter 3 table 3.2 and figure 3.5.

Site	Location	Land use	Runoff BC (mg/L)	Runoff Ctot (mg/L)	Runoff DOC BC (mg/L)	Runoff DOC Ctot (mg/L)	Sediment BC (mg)	Sediment Ctot (mg/g)
Fa	II	Forest	0.00	0.19	0.00	0.18	0.00	0.06
Fa	III	Forest	0.01	0.44			0.00	0.06
Fa	III	Forest	0.00	0.11	0.00	0.12		
Fa	IV	Forest	0.00	-0.14	0.00	0.12	0.00	0.02
Fb	I	Forest	0.00	0.15	0.00	0.13	0.00	0.00
Fb BC	I	Forest	0.00	0.15	0.00	0.16	0.00	0.06
Fb BC	III	Forest	0.00	0.18	0.00	0.23	0.00	0.09
Fb BC	III	Forest	0.00	0.21	0.00	0.23	0.00	0.08
Fb	III	Forest	0.00	0.10	0.00	0.08	0.00	0.01
10a	II	Nappier grass	0.00	0.16			0.00	0.02
10b	I	Arrow root	0.00	0.21	0.00	0.14	0.00	0.02
10b	I	Maize	0.00	0.18	0.00	0.19	0.00	0.04
10b	I	Maize	0.00	0.15	0.00	0.15	0.00	0.03
10b	III	Maize	0.00	0.20	0.00	0.14	0.01	0.41
10b	III	Pasture	0.00	0.15	0.00	0.13		
10b	V	Fallow	0.00	0.16			0.01	0.29
10b	VI	Maize	0.00	0.13	0.00	0.09	0.01	0.26
10b	VI	Fallow						
16a	I	Riverine veg	0.32	24.89	-0.05	-2.95	0.00	0.03
16a	I	Riverine veg	0.00	0.19	0.00	0.17		
16a	II	Beans						
16a	II	Riverine veg	0.00	0.14	0.00	0.13	0.01	0.36
16a	II	Pasture						

16a	II	Kale	0.00	0.18	0.00	0.16	0.00	0.06
16a	III	Maize	0.00	0.21			0.07	2.73
16a	III	Maize	0.00	0.19	0.00	0.12	0.00	0.04
16a	IV	Tea	0.00	0.17	0.00	0.09	0.25	14.54
16a	V	Road	0.00	0.13	0.07	3.00		
16a	V	Road						
16a	V	Grass playground	0.00	0.10	0.01	0.33	0.00	0.15
16a	V	Grass playground						
16b	I	Fallow	0.00	0.17	0.00	0.18	0.00	0.04
16b	I	Fallow	0.00	0.14	0.00	0.14	0.00	0.03
16b	II	Fallow						
16b	II	Fallow						
10b	II	Pasture						
16b	III	Bare playground						
16b	III	Bare playground	0.00	0.19	0.00	0.16	0.00	0.12
16b	IV		0.00	0.15	0.00	0.15	0.00	0.06
16b	IV		0.00	0.00	0.00	0.05	0.00	0.03
62a	I	Eucalyptus						
50a	I	Eucalyptus	0.00	0.17			0.00	0.06
50a	I	Eucalyptus	0.00	0.17	0.00	0.16	0.07	4.92
50a	II	Eucalyptus	0.00	0.19	0.00	0.16	0.00	0.02
50a	II	Eucalyptus						
50a	II	Eucalyptus	0.00	0.14	0.00	0.06	0.00	0.04
50a	III	Nappier grass	0.00	0.12	0.00	0.06	0.00	0.07
50a	III	Fallow	0.00	0.14	0.00	0.17	0.00	0.05
50a	III	Fallow	0.00	0.14	0.00	0.16	0.01	0.45
50a	IV	Fallow	0.00	0.15	0.00	0.14	0.00	0.03
50a	IV	Sugarcane	0.00	0.19	0.00	0.18	0.00	0.03
50a	IV	Fallow	0.00	0.15			0.03	1.48
50a	V	Sweet potato	0.00	0.18	0.00	0.17	0.00	0.08
50a	V		0.00	0.19	0.00	0.19	0.00	0.04
50a	V	Maize	0.09	5.32	0.00	0.17	0.06	2.53
50a	VI	Nappier grass	0.00	0.23	0.00	0.20	0.00	0.06
50a	VI	Pasture	0.00	0.18	0.00	0.18	0.00	0.09
50a	VII	Maize	0.00	0.15	0.00	0.14	0.00	0.09
50a	VII	Ploughed field	0.00	0.18	0.00	0.17	0.04	1.81
50a	VII	Bare homestead	0.00	0.16	0.00	0.17	0.01	0.47
50b	III		0.00	0.14	0.00	0.15	0.00	0.05
50b	IV	Road	0.00	0.12			0.00	0.05
50b	V	Maize	0.00	0.13	0.00	0.13	0.00	0.04
50b	V	Grass in homestead			0.00	0.13	0.00	0.12

Table 3.S19. Data from chapter 3 table 3.2 and figure 3.5.

Site	Location	Land use	Runoff Bctot (g ha^{-1})	Runoff Ctot (g ha^{-1})	Runoff DBC (g ha^{-1})	Runoff DOC (g ha^{-1})	Sediment BC (g ha^{-1})	Sediment Ctot (g ha^{-1})
Fa	II	Forest	7.63	580.09	9.60	534.90	0.00	0.01
Fa	III	Forest	17.69	1301.03			0.00	0.01
Fa	IV	Forest	-6.34	-348.92	6.40	291.43	0.00	0.01
5a	II	Nappier grass	10.59	463.07			0.00	0.01
5b	I	Arrow root	2.72	161.21	2.54	107.76	0.00	0.01
5b	I	Maize	6.44	496.95	11.12	504.84	0.00	0.01
5b	I	Maize	7.76	359.19	8.64	362.04	0.00	0.01
5b	III	Maize	6.87	563.68	8.16	386.04	0.00	0.09
5b	V	Fallow	7.37	539.61			0.00	0.06
5b	VI	Maize	6.17	353.67	4.71	262.92	0.00	0.06
10a	I	Riverine veg	388.93	30614.06	-61.76	-3630.13	0.00	0.01
10a	II	Riverine veg	8.20	377.89	8.82	366.83	0.00	0.08
10a	II	Kale	6.16	357.53	7.78	320.02	0.00	0.01
10a	III	Maize	6.73	529.44			0.02	0.60
10a	III	Maize	7.67	443.57	3.65	273.82	0.00	0.01
10a	IV	Tea	10.93	496.97	5.88	258.13	0.05	3.19
10a	V	Grass playground	5.56	242.42	13.56	824.93	0.00	0.03
10b	I	Fallow	9.00	421.39	6.49	452.66	0.00	0.01
10b	I	Fallow	4.74	327.93	7.21	314.03	0.00	0.01
10b	III	Bare playground	7.65	620.31	12.06	521.34	0.00	0.03
10b	IV		10.69	458.81	7.92	458.97	0.00	0.01
10b	IV				3.60	161.38	0.00	0.01
62a	I	Eucalyptus	4.02	183.77			0.00	0.01
62a	I	Eucalyptus	9.68	398.36	10.47	379.46	0.01	1.08
62a	II	Eucalyptus	1.92	138.82	2.73	115.80	0.00	0.00
62a	II	Eucalyptus	7.89	411.71	4.49	184.33	0.00	0.01
62a	III	Nappier grass	5.65	331.13	4.72	152.36	0.00	0.02
62a	III	Fallow	1.69	97.39	1.96	118.47	0.00	0.01
62a	III	Fallow		5.74	271.63	5.34	309.85	0.00
62a	IV	Fallow	7.36	432.72	7.18	421.68	0.00	0.01
62a	IV	Sugarcane	7.44	461.26	7.53	440.99	0.00	0.01
62a	IV	Fallow	6.44	406.11			0.01	0.32
62a	V	Sweet potato	12.18	538.95	6.67	488.01	0.00	0.02
62a	V		6.77	313.59	6.93	318.52	0.00	0.01
62a	V	Maize	276.84	16478.11	12.51	535.57	0.01	0.56
62a	VI	Nappier grass	7.25	563.94	9.52	500.61	0.00	0.01
62a	VI	Pasture	6.36	456.21	10.54	449.09	0.00	0.02

62a	VII	Maize	8.35	333.94	8.14	323.12		0.00		0.02
62a	VII	Ploughed field	5.28	412.08	8.27	377.60	0.01		0.40	
62a	VII	Bare homestead	5.24	381.78	5.18	401.54		0.00		0.10
62b	III		4.52	331.83	4.59	356.12		0.00		0.01
62b	IV	Road	5.31	235.17				0.00		0.01
62b	V	Maize	4.26	243.87	4.50	245.83	0.00		0.01	
62b	V	Grass in homestead		6.71	322.20	0.00		0.03		