Carbohydrate Characteristics of Cotton Plant Biomass Products and Byproducts

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Abstract

Biomass materials of the cotton plant are useful as soil amendment, animal feed, bioenergy source, and certain industrial raw materials. In this study, whole cotton plants were collected at mid-season and just before harvest. These plant samples were separated into six (mid-season) or eight (pre-harvest) biomass fractions: main stems, leaf blades, branches, petioles, roots, and the reproductive part (or bur, peduncles+bracts, and seeds). The contents of seven carbohydrates (fucose, arabinose, rhamnose, galactose, glucose, xylose, and mannose) as well as strong-acid extractable glucose, cellulose, and hemicelluloses in these biomass fractions were determined using standard procedures. We found growth stage affected the relative contents of some, but not all, measured parameters. Regression analysis revealed that the contents of some parameters were well correlated with each other, but other parameters were quite independent of each other. The information reported in this work would be helpful in exploring and optimizing management practices and processing strategies in utilizing these cotton crop biomass materials as valuable and renewable natural resources.

Materials

Figure 1. Plant parts collected mid-season

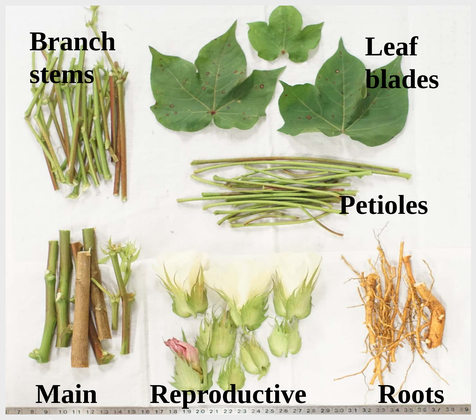


Figure 2. Plant parts collected pre-defoliation

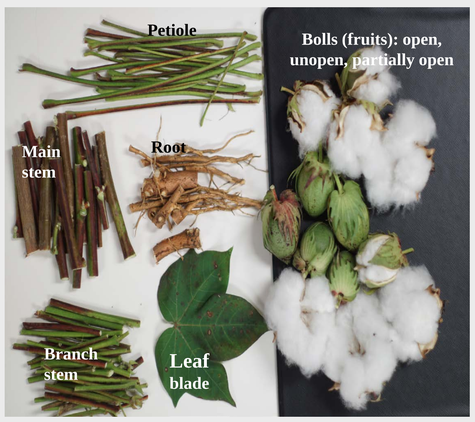
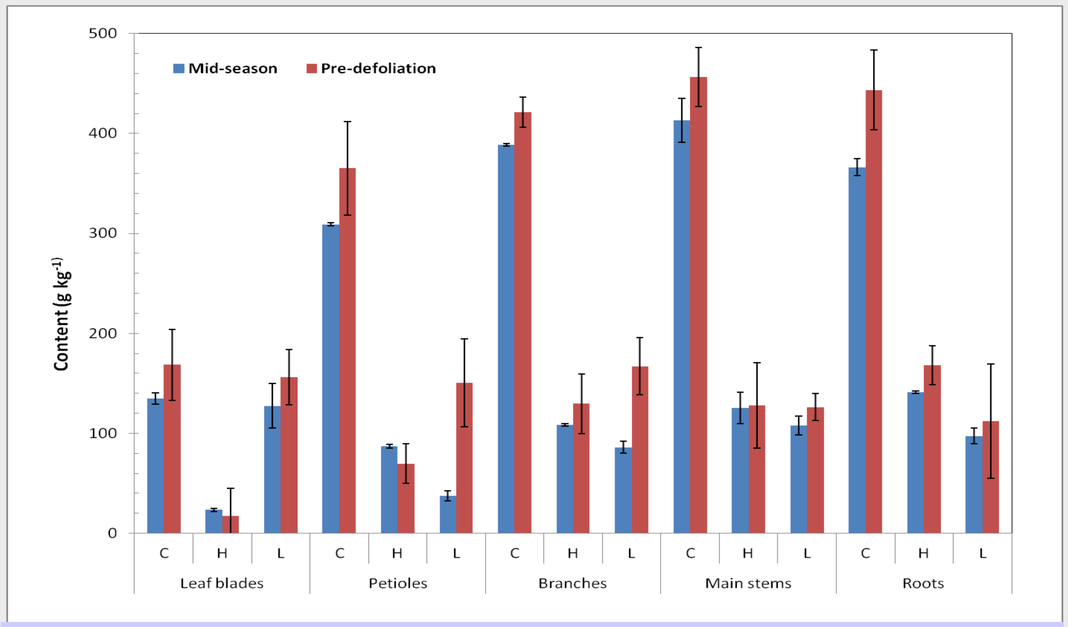


Table 1. Contents of seven carbohydrates in cotton plant parts collected at mid-season (MS) and pre-defoliation (PD) phases. GM/AX: (Galactose+Mannose)/(Arabinose+Xylose). Data are present in g kg^{-1} of dry matter with average (A) and standard deviation (SD, n=4).

		Fucose		Rhamnose		Arabinose		Galactose		Glucose		Xylose		Mannose		GM/AX	
		MS	PD	MS	PD	MS	PD	MS	PD	MS	PD	MS	PD	MS	PD	MS	PD
Leaf blades	A	0.9	1.1	10.9	9.9	17.9	14.0	20.9	23.9	33.8	30.0	12.1	14.3	5.6	8.6	0.89	1.15
	SD	0.1	0.1	2.0	1.3	2.2	1.4	2.1	2.0	3.6	2.0	2.4	1.7	1.0	0.2	0.06	0.05
Petioles	A	1.5	1.8	11.8	13.5	23.9	23.7	17.4	23.7	43.0	22.3	40.8	56.5	7.7	8.1	0.40	0.40
	SD	0.2	0.1	1.2	1.7	4.1	4.9	2.7	3.2	8.0	3.8	10.9	5.8	1.3	0.9	0.05	0.01
Branches	A	0.7	1.0	7.4	8.6	15.5	13.2	12.3	13.2	66.1	23.9	61.9	82.2	5.8	6.1	0.23	0.20
	SD	0.1	0.2	0.6	0.6	1.3	1.8	0.6	1.1	7.3	8.5	3.2	3.4	0.6	0.2	0.00	0.01
Main stems	A	0.3	0.8	4.8	7.1	7.1	9.7	7.0	9.3	56.3	40.4	40.0	71.7	3.2	5.3	0.22	0.19
	SD	0.1	0.2	1.0	1.4	1.0	1.1	0.9	0.9	8.9	14.2	7.6	19.2	1.3	0.5	0.03	0.06
Roots	A	0.2	0.4	5.2	5.0	6.4	7.1	6.1	7.1	65.3	37.9	27.5	65.1	2.8	3.2	0.26	0.14
	SD	0.1	0.1	0.4	0.8	0.7	0.8	0.5	0.5	8.8	9.6	2.3	7.4	0.2	0.3	0.03	0.01

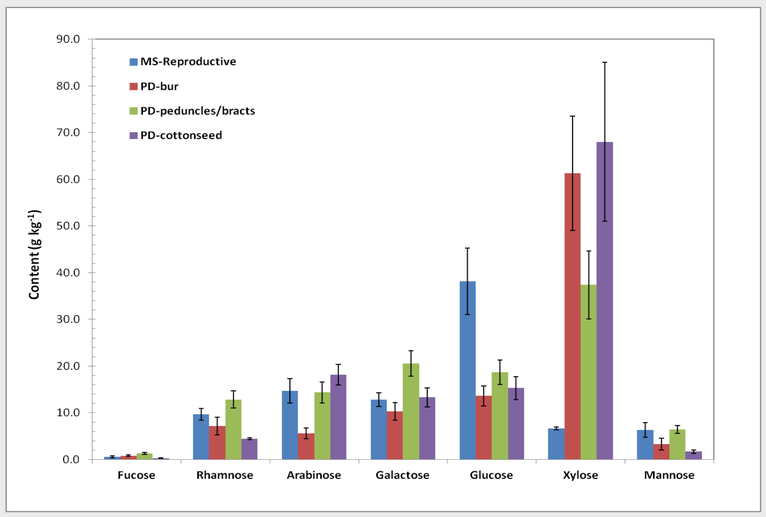
- Glucose, xylose are the major carbohydrates. Little fucose is present.
- Content of glucose in the plant biomass decreased with the growth season.
- Xylose is rich in petioles, branches, main stems, and roots. Contents of xylose in the plant biomass increased with the growth season.
- Galactose and arabinose are moderate in content, and their contents changed from high in leaf blades to low in roots.
- Contents of galactose and manniose also increased consistently, but in a lesser extent, in all five parts with the growth season.

Figure 3. Cellulose (C), hemiscellulose (H) and acid detergent lignin (L) in cotton plant parts at mid-season and pre-defoliation stages



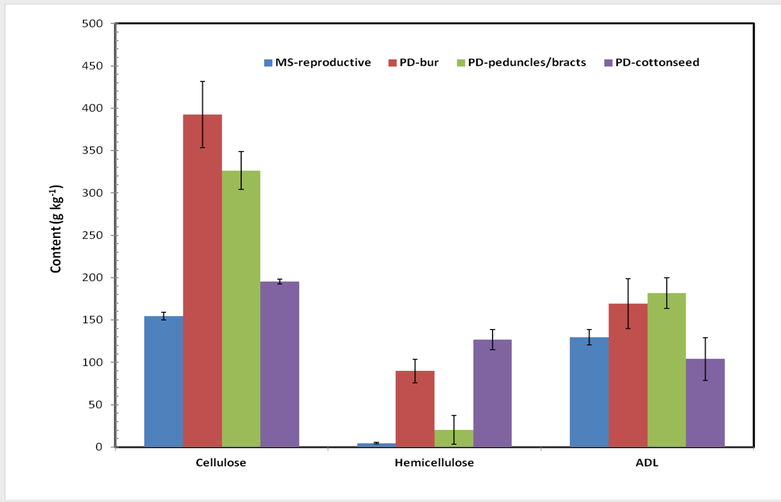
- General order: C>L ~ H.
- Contents of cellulose and hemicellulose are lower in leaf blades than other plant parts.
- Content of acid detergent lignin is at the same level in all plant parts except petioles at the mid-season.
- Contents of cellulose in plant biomass increased with the growth season.
- Increase of lignin with growth is high in petioles and branches, but not apparent in other parts.
- Hemicellulose basically remained the same at the both growth stages.

Figure 4. Contents of carbohydrates in cotton reproductive parts in mid-season (MS) and pre-defoliation (PD) phases.



- Lint (fiber) part of the cotton boll was separated but not analyzed for the pre-defoliation sample.
- Content of glucose is higher in reproductive part at mid-season than in boll parts at pre-defoliation.
- Content of xylose is lower in reproductive part at mid-season than in boll parts at pre-defoliation.

Figure 5. Cellulose (C), hemiscellulose (H) and acid detergent lignin (L) in cotton reproductive parts at mid-season and pre-defoliation stages



- General order: C>L>H.
- Contents of cellulose and hemicellulose are lower in reproductive part at mid-season than in boll parts at pre-defoliation.
- Content of cellulose is lower in cottonseed part of bolls.
- Content of hemicellulose is lower in peduncles/bracts than burs and cottonseed of bolls.

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