Amino acid and carbohydrate distribution in cotton plant biomass products and byproducts

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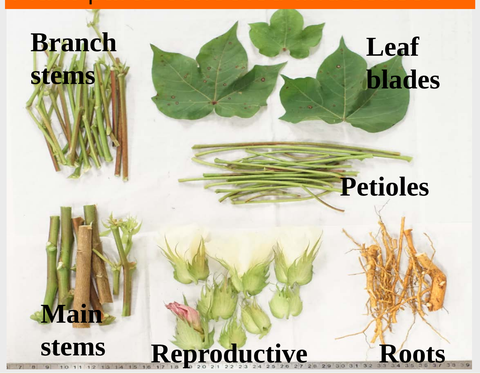
Abstract

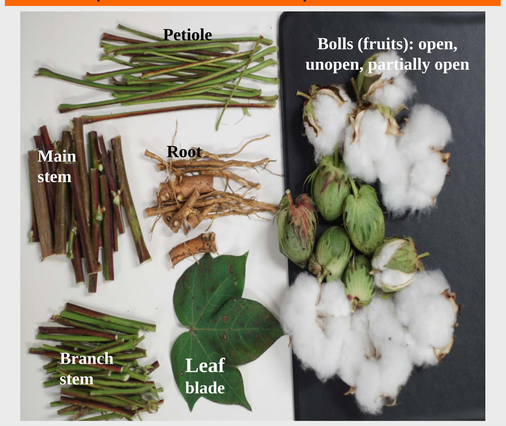
Nutrient management is essential in cotton plant growth. High quality cotton biomass products and byproducts can be used as animal feed and industrial raw materials. To study the effect of nutrient management on cotton fiber and biomass quality, we collected whole cotton plants from fertilizer treatments and separated them into different biomass fractions -- main stems, leaf blades, branches, petioles, roots, and reproductive part (midseason) or bur, peduncles+bracts, and seed cotton (harvest ready). The contents of amino acids and selected carbohydrates in these biomass materials were determined. Both essential and nonessential amino acids were enriched in cotton leaf blades and reproductive parts, compared to other plant parts. The distribution pattern of the selected carbohydrates differed from that of amino acids, as higher contents of carbohydrate, especially the polymeric cellulose, hemicelluloses, and lignin, were found in root, main stem and branch parts. Nutritional carbohydrates and amino acids had further accumulated in the reproductive seed part with the growth. The information reported in this work will be helpful in exploring and optimizing management practices and processing strategies for using cotton crop biomass materials as valuable and renewable natural resources.

Materials

Plant parts collected mid-season



Plant parts collected pre-defoliation



Carbohydrate and amino acid monomers were measured by acid extraction (H_2SO_4 and methanesulfonic acid, respectively), anion chromatographic separation, and pulsed amperometric detection

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 presented 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 advancing growth.
- Xylose is rich in petioles, branches, main stems, and roots. Contents of xylose in the plant biomass increased with advancing growth.
- 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 to a lesser extent, in all five parts with advancing growth.

Fig. 1. Contents of essential amino acids in cotton plant parts at mid-season and pre-defoliation stages

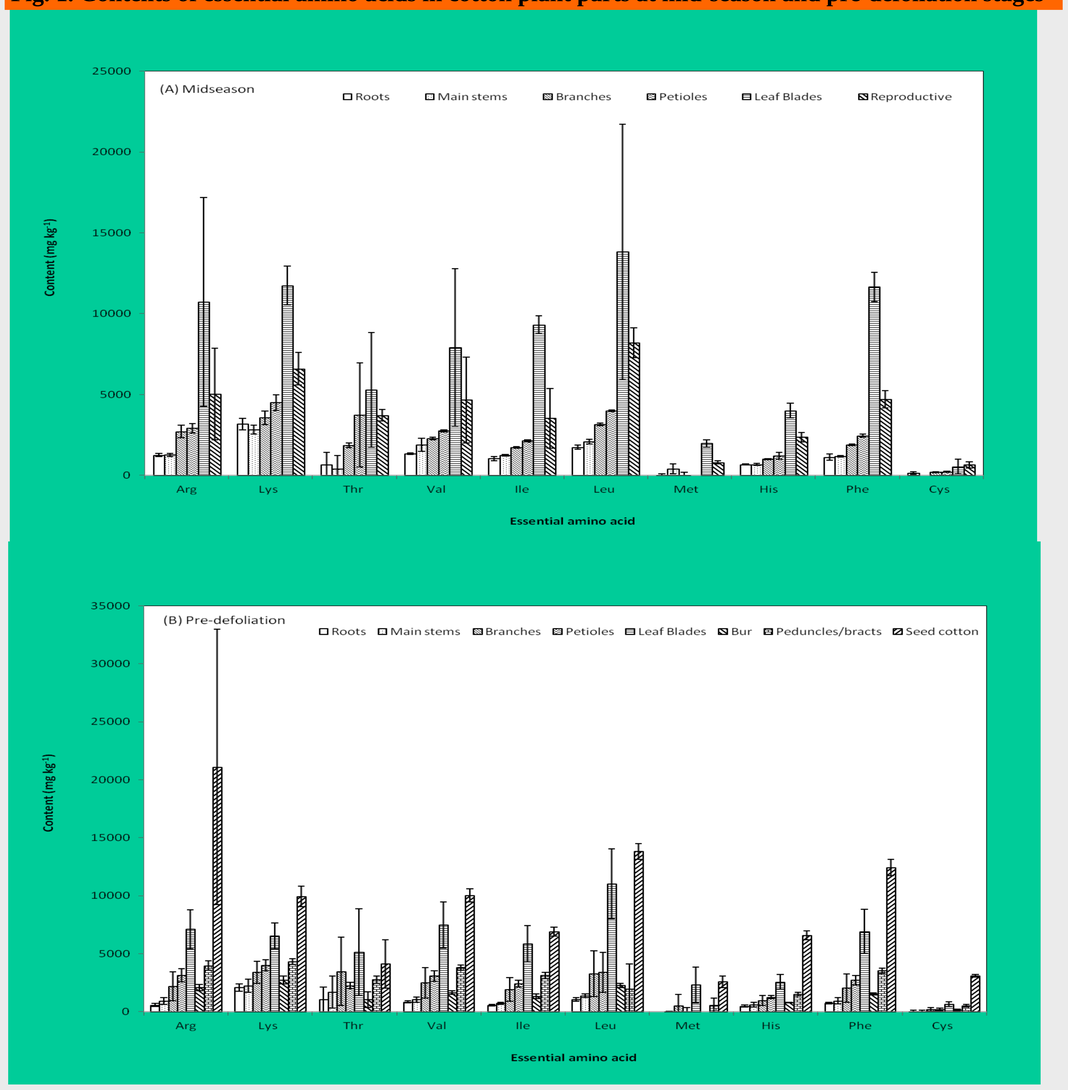
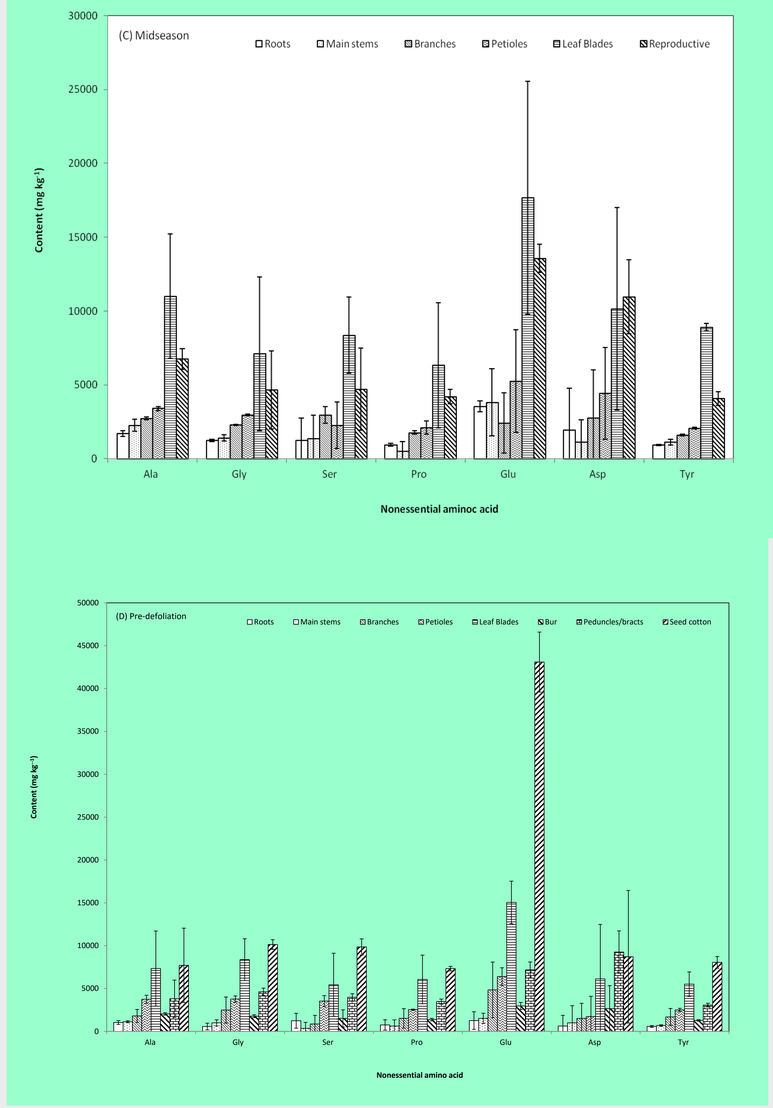


Fig. 2. Contents of non-essential amino acids in cotton plant parts at mid-season and pre-defoliation stages



- Leu, Lys, Phe, and Arg are the major EAA, of which the highest content is >10 g/kg each.
- Glu, Ala, and Asp are the major NAA, of which the highest content is around 10 g/kg or higher each.
- All biomass samples have shown the similar orders in the relative abundances of the 10 EAA and of the 7 NAA.

- The distribution patterns of AA among the different biomass samples are different from those of carbohydrates
- Highest contents of EAA and NAA are found in leaf blade and reproductive biomass samples.
- At mid-season, contents of AA in leaf blades are greater than those in reproductive part.
- Both EAA and NAA increased in the reproductive parts with advancing growth, leading to higher contents of AA in seed cotton than in blade leaf at the pre-defoliation stage.

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