METAL ANALYSIS OF COTTON

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Abstract

Metal analysis is of interest to the cotton scientific community for the role it plays in cotton development and processing. Seven varieties were analyzed for 8 metals ions using Inductively Coupled Plasma-Optical Emission Spectroscopy. The metals analyzed on the surface of cottons were potassium, sodium, magnesium, calcium, iron, copper, zinc, and manganese. The cotton varieties were all grown in the same field in Maricopa, AZ. To explore this concept, the metal parameters were compared to the cotton quality parameters found using the High Volume Instrument (HVI). Two field conditions were explored; (dry) or rain-fed only and well-watered or (irrigated). The SAS statistical program uncovered correlative relationships between the metals, varieties, and fiber quality parameters.

Introduction

Metals on the surface of cotton lint have previously been studied in the literature (Heinzelman and O'Connor, 1950) Potassium was found to exist in the highest abundance due to the major role it plays in the development of cotton (Dhindsa, 1975). Copper and iron have been correlated to the yellowing of finished denim goods (Brushwood and Perkins, 1994). Magnesium has been determined to affect dyeing at elevated temperatures. Calcium and magnesium were observed to form metal-dye water insoluble complexes following scouring of the fiber (Gamble, 2010).

Methods

Seven cotton varieties were grown on the same field in Maricopa, AZ. Those varieties were Acala 1517, DP393, NM 1303, FM 958, MD-DC, PX06520-42-2-3, and AU51038. Two field conditions were analyzed; dry and irrigated. The HVI parameters including micronaire, uniformity index, upper half mean length, short fiber content, strength, elongation, Rd, and +b were determined. Sample preparation included taking 0.5 g of cleaned and ginned cotton lint and placing it in a Teflon vessel which was then inserted into a composite sleeve. Pre-digestion was carried out by adding 20mL of a 1:1 mixture of 70% nitric acid and Millipore water to the vessels and allowing the samples to sit for 10 minutes. Next, these vessels were then inserted into a carousel taking care to have equal weight of the samples on all sides. The carousel was then inserted to MARS6 microwave digestion instrument. Following digestion, the samples were allowed to sit 10 minutes to allow them to cool. The samples were then diluted 2mL digested sample into 25mL of Millipore water. Then, the samples were run on the inductively coupled plasma-optical emission spectrometer (ICP-OES). Samples were run in triplicate.

Results

When determining the relationships between metals and HVI parameters, it was discovered that potassium and +b had a highly inverse linear relationship with an R-squared value of 0.9341. This was observed for the PX6520-42-2-3 variety.

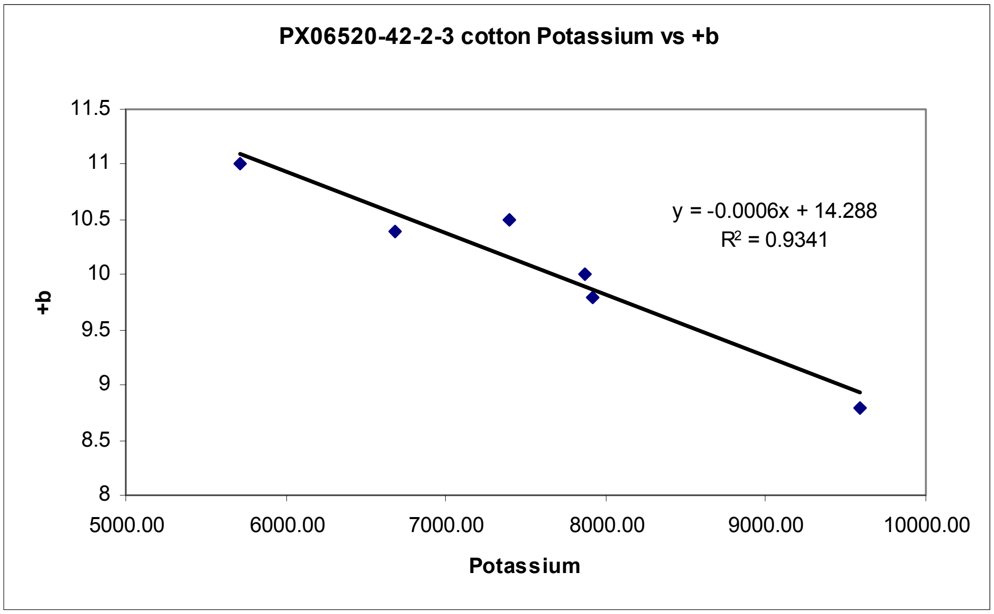

Figure 1. The effect of potassium concentration on +b for PX06520-42-2-3 cotton variety.

Table 1 shows the effect of field conditions on metals and fibers. In coincidence with the previous literature, potassium, calcium, and magnesium were present in the highest abundance for both the dry and wet conditions. For the HVI parameters, only the short fiber content gave a significantly higher value under the dry conditions as opposed to the wet conditions.

Table 1. Effect of field conditions on Metals and Fiber quality

Variable	n[a]	Dry		Wet		n	Combined	
		Mean*	Std Dev	Mean*	Std Dev		Mean*	Std Dev
K	21	5429.61	965.59	5712.65	1495.84	42	5571.13	1251.72
Ca	21	854.08	252.73	783.30	195.15	42	818.69	225.87
Mg	21	705.20	311.80	765.20	327.13	42	735.20	317.10
Na	21	103.03	49.15	104.08	44.21	42	103.55	46.18
Cu	21	30.00	9.33	29.33	9.92	42	29.66	9.52
Fe	21	241.46	147.82	238.49	150.22	42	239.98	147.21
Mn	21	4.10	1.00	3.86	1.03	42	3.98	1.01
Zn	21	46.65	64.10	47.33	65.67	42	46.99	64.10
Micronaire	21	5.39	0.30	5.36	0.23	42	5.37	0.26
UHM	21	1.06	0.06	1.12	0.05	42	1.09	0.06
Uniformity	21	80.63	1.12	82.26	1.59	42	81.45	1.59
Strength	21	29.30	3.43	30.83	2.78	42	30.07	3.18
Elongation	21	4.42	0.75	4.49	0.78	42	4.45	0.76
Short Fiber	21	9.84	1.01	8.74	0.80	42	9.29	1.06
Rd	21	77.94	1.31	79.63	2.13	42	78.79	1.94
+b	21	9.79	0.54	9.25	0.53	42	9.52	0.60

* Metals measured in µg/g, [a] designates seven cotton with three replicates

Table 2. Correlations of Metals and Fiber quality parameters.

Variable	N	Mean	STD	Correlations of Metals & Fiber Quality (r)							
				K	Ca	Mg	Na	Cu	Fe	Mn	Zn
K	42	5571.00	1252.00	1							
Ca	42	818.69	225.87	0.32 *	1						
Mg	42	735.20	317.10	0.15	0.06	1					
Na	42	103.55	46.18	0.40 †	0.17	0.52 ‡	1				
Cu	42	29.66	9.52	-0.09	-0.28	-0.80 ‡	-0.51 ‡	1			
Fe	42	239.98	147.21	-0.39 *	-0.19	-0.71 ‡	-0.39 *	0.66 ‡	1		
Mn	42	3.98	1.01	0.41 †	0.32 *	0.15	0.15	-0.25	-0.47 †	1	
Zn	42	46.99	64.10	-0.22	-0.21	-0.33 *	-0.18	0.44 †	0.48 †	-0.26	1
Micronaire	42	5.37	0.26	0.07	-0.15	0.46 †	0.34 *	-0.33 *	-0.44 †	-0.09	-0.42 †
UHM	42	1.09	0.06	0.16	0.20	-0.18	-0.04	-0.08	-0.21	0.26	-0.37 *
Uniformity	42	81.45	1.59	0.23	0.17	-0.34 *	-0.07	0.14	0.15	0.12	-0.24
Strength	42	30.07	3.18	0.19	0.30	-0.19	0.16	-0.09	-0.18	0.21	-0.43 †
Elongation	42	4.45	0.76	0.40 †	0.27	0.31 *	0.41 †	-0.36 *	-0.43 †	0.23	-0.82 ‡
Short Fiber	42	9.29	1.06	-0.30	-0.19	0.13	-0.08	0.02	0.03	-0.24	0.29
Rd	42	78.79	1.94	-0.38 *	-0.38 *	-0.06	-0.34 *	0.32 *	0.32 *	-0.42 †	0.37 *
+b	42	9.52	0.60	0.18	0.30	0.13	0.17	-0.27	-0.41 †	0.22	-0.65 ‡

*p<0.05, †p<0.01, ‡p<0.001; r = correlation coefficient

Table 2 depicts the metals and HVI properties correlations. Three distinct correlations were analyzed-the probability at 0.05, 0.01, and 0.001. When analyzing the table for metals, magnesium correlated with sodium, copper, and iron at the most significant probability level possible, 0.001. Similarly, sodium had a highly significant correlation with copper. Zinc had a highly significant correlation with elongation, and +b.

Summary

A study was conducted to probe the relationships that exist between metals, cotton varieties, and HVI parameters. Metal ions were detected and investigated on cotton plants under dry and well-watered field conditions. Statistically, there was little difference on the metal ion content. This may be due to the fact that all of the cotton varieties were grown on the same field. Microwave acid digestion and inductively coupled plasma-optical emission spectroscopy were the methods of choice to follow the abundance of 8 metals (potassium, calcium, magnesium, sodium, iron, copper, manganese, and zinc). The correlations between metals, HVI parameters, and cotton varieties were noted and indicate preliminary relationships to the differences in metal ion content on cotton. It is necessary to do a multi-year and multi-location investigation to study interaction effect due to location and field conditions.

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References

Brushwood, D.E. and H.H. Perkins Jr., Determining the Metal Content of Cotton. 1994. Analytical Techniques, Vol. 26, No. 3, pp. 32-35.

Dhindsa, R.S. 1975. Plant Physiology, Vol. 56 p.394.

Gamble, G. 2010. Examination of Factors Affecting Post-Scoured Fiber Metal Content. Proceedings Beltwide Cotton Conferences, pp.1663.

Heinzelman, D.C. and O'Connor, R.T. 1950. Trace Metals in Cotton Fiber. Textile Research Journal, pp. 805-807.