Exploring Cotton Bale Fiber Quality Variability within Round Modules Employing John Deere's HID System

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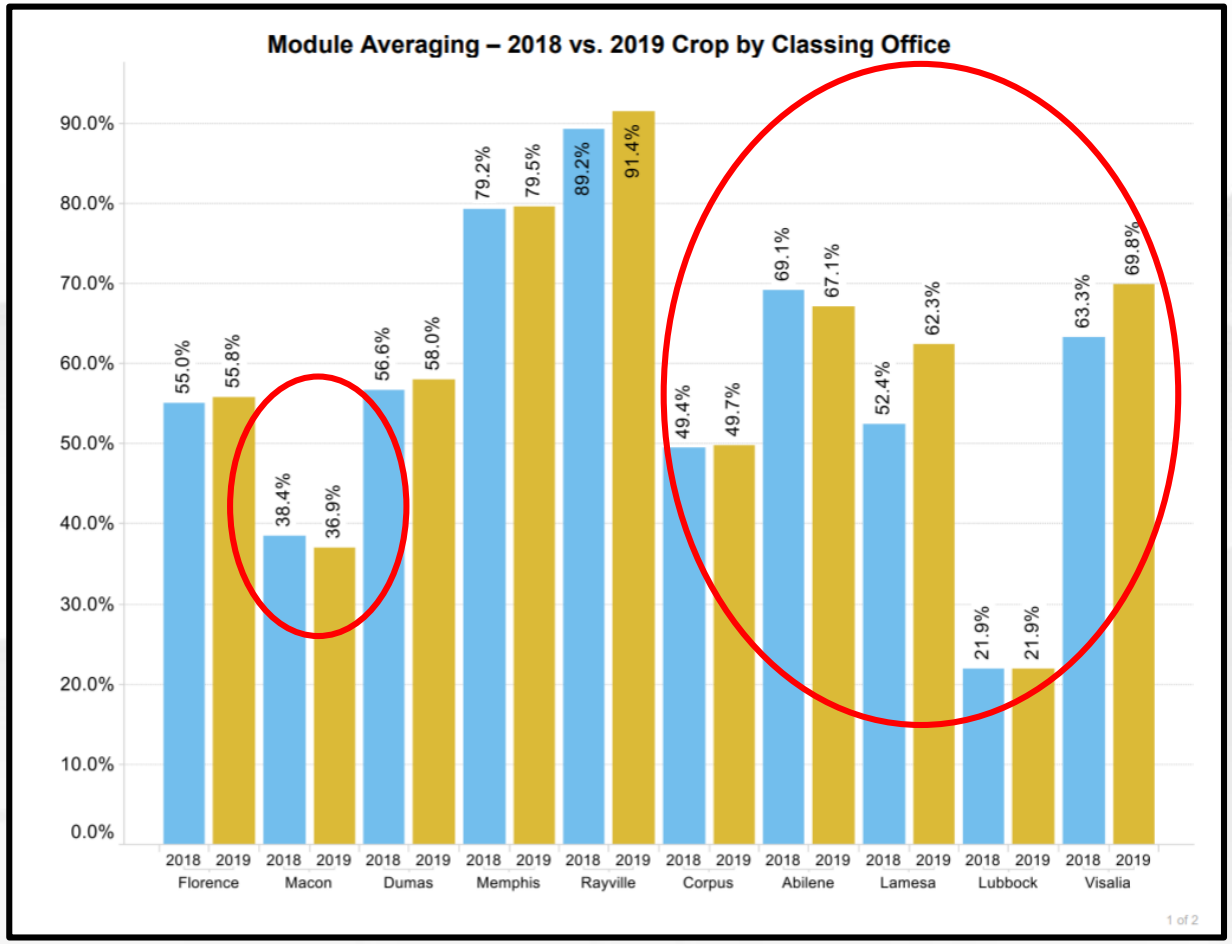
Cotton Module Averaging

- Program originally started in 1991
  - Still a voluntary program
- Each bale submitted is compared to the average
  - fiber strength, micronaire, length, and uniformity
- “Statistical studies show that module averaging improves the accuracy of quality measurements” (2019,USDA-AMS)



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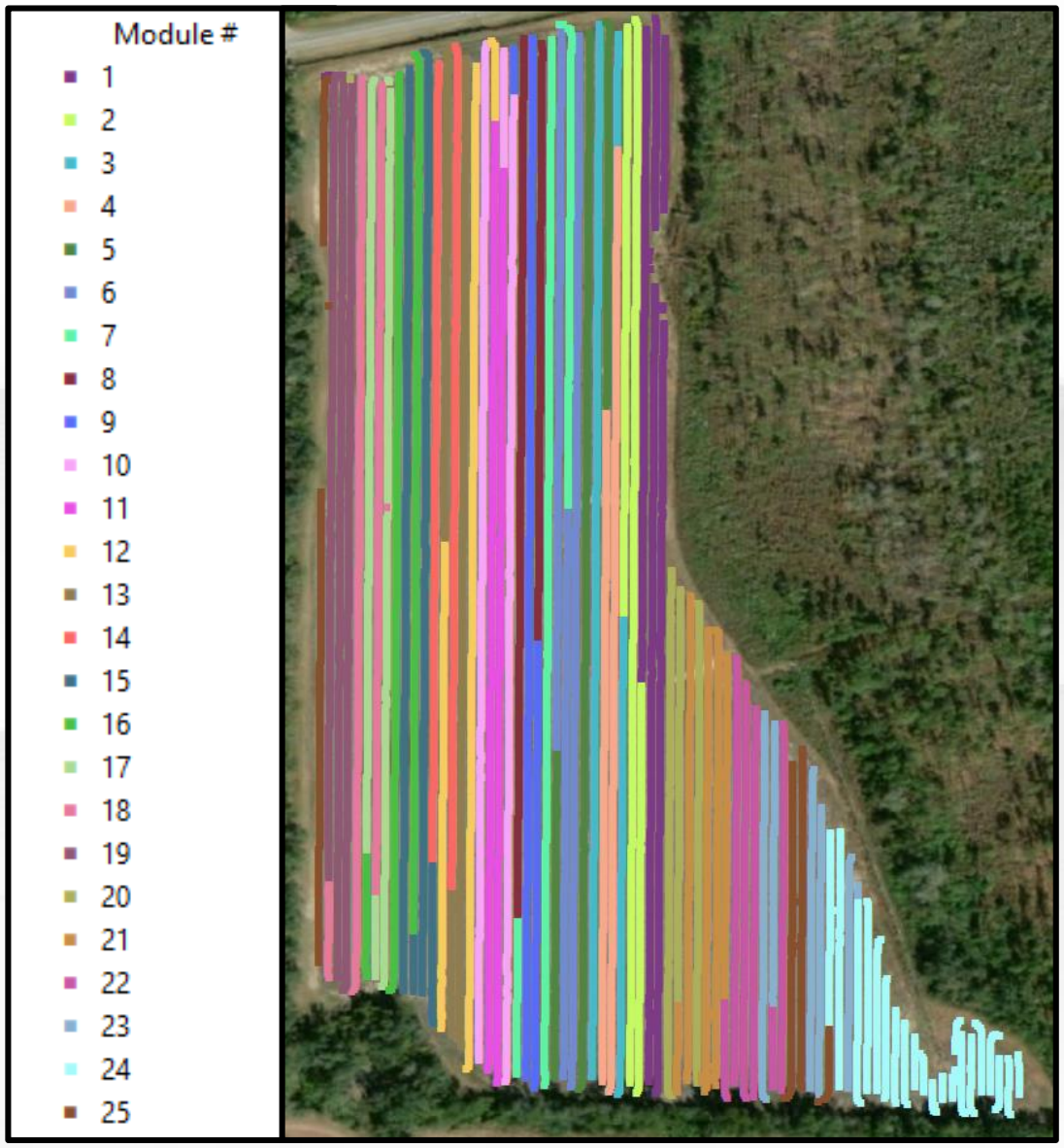
Cotton Module Averaging

- This is typically done with bales produced from a traditional module
- With round modules, four modules or a “load”, will be averaged together to give an overall average assigned to all four
- Only up to 50 bales can be averaged for a module

Research Question

Do averaged modules accurately show the true variability of fiber quality between bales from each module?



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Methodology for UGA HID Project Module Averaging

- Python program was written
  - Originally done using an excel calculator

- Allows for the input of bale report data and automated creation of a new excel file with averaged columns by load number

```
@author: lmf30622
"""

#Module_averaging tool
#Luke Fuhrer


import pandas as pd
from pandas import DataFrame
from tkinter import Tk
from tkinter.filedialog import askopenfilename


Tk().withdraw()
filename = askopenfilename() #generates window to select bale report
print(filename)

df = pd.read_excel(filename) #creates dataframe from excel file
df = DataFrame(df, columns=['Load','Lf','Mic','Str','Rd','b','Tr','Unif','Len','Loan Rat', 'Loan Value'])
df_avg = df.groupby('Load')['Lf','Mic','Str','Rd','b','Tr','Unif','Len','Loan Rat', 'Loan Value'] #groups data by load number
df_avg = df.transform('mean').drop_duplicates(['Lf','Mic','Str','Rd','b','Tr','Unif','Len','Loan Rat', 'Loan Value']) #averages quality data
print (df_avg)

df_avg.to_excel(r'C:\git_repo\ HH_AVG_FIBER.xlsx', index=False) #creates new excel file from averaged values
```

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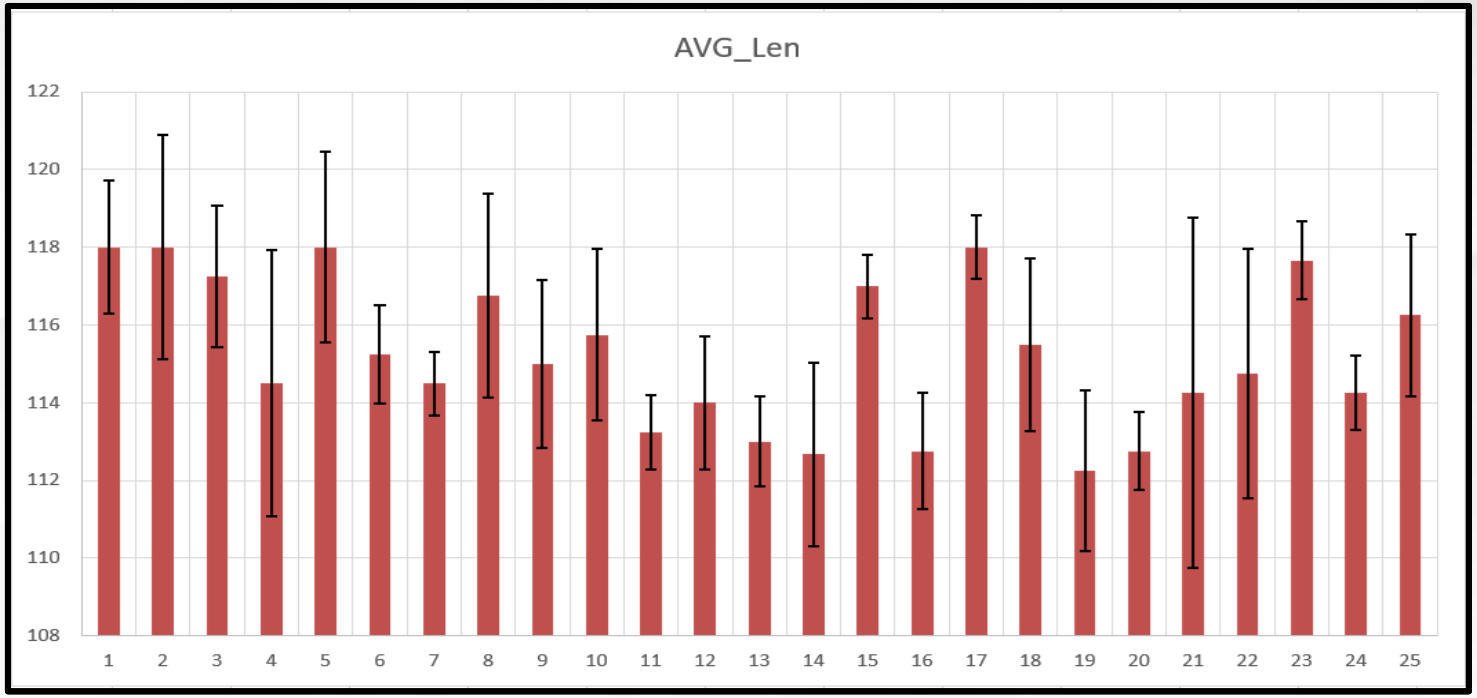
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Bale #	NetWt	Farm ID	Load	Field ID	Pk	Gr	Lf	St	Mic	Ex	Rm	Str	CGr	Rd	b	Tr	Unif	Len	Elong	Loan Rat	Loan Value
2	953817	479	2632	160210	FIRETOWE	1	31	3	35	3.9			32.1	31-1	78.1	8.3	3	79.7	110		54.3	260.1
3	953860	507	2632	160221	FIRETOWE	1	31	3	35	4.2			31.7	31-1	79	7.9	3	80	109		54.8	277.84
4	953798	469	2632	160205	FIRETOWE	1	31	3	36	4.1			28.1	31-1	79.7	7.8	3	78.7	111		55.1	258.42
5	953824	488	2632	160212	FIRETOWE	1	31	3	36	4			29.9	31-1	78.7	8	3	78.1	111		55.15	269.13
6	953792	486	2632	160204	FIRETOWE	1	31	3	36	4.1			28.4	31-1	79.6	7.4	3	79.4	111		55.2	268.27
7	953834	506	2632	160214	FIRETOWE	1	31	3	36	4			28.4	31-1	80.1	7.4	2	79.6	113		55.2	279.31
8	953818	486	2632	160210	FIRETOWE	1	31	3	36	4			29.9	31-1	78	8.2	3	79.2	112		55.25	268.52
9	953870	498	2632	160224	FIRETOWE	1	31	3	36	4.2			30.6	31-1	78.9	8	3	78.8	112		55.35	275.64
10	953787	476	2632	160202	FIRETOWE	1	31	3	36	3.9			30.9	31-1	78.3	8.2	3	79.4	112		55.45	263.94
11	953872	482	2632	160224	FIRETOWE	1	31	3	36	4.1			30.8	31-1	78.3	8	4	79.5	113		55.45	267.27
12	953799	485	2632	160205	FIRETOWE	1	31	3	36	4.2			30.1	31-1	80	7.7	2	79.6	113		55.45	268.93
13	953874	485	2632	160225	FIRETOWE	1	31	3	36	4.1			30.6	31-1	78.7	7.9	3	79.5	112		55.45	268.93
14	953868	499	2632	160223	FIRETOWE	1	31	3	36	4.1			30.3	31-1	78.2	8.1	3	79.5	112		55.45	276.7
15	953816	483	2632	160210	FIRETOWE	1	31	3	37	4			28.3	31-1	79.1	7.8	3	79	114		55.6	268.55
16	953785	463	2632	160202	FIRETOWE	1	31	3	36	3.9			31.2	31-1	78.1	8	3	79.1	112		55.65	257.66
17	953852	488	2632	160219	FIRETOWE	1	31	2	36	4.2			30.3	31-1	79.1	8	2	79.4	111		55.65	271.57
18	953866	491	2632	160222	FIRETOWE	1	31	3	37	4.2			29.4	31-1	79.2	7.5	3	79.9	114		55.65	273.24
19	953867	493	2632	160223	FIRETOWE	1	31	3	37	4.2			29.6	31-1	78.7	8.2	4	79.6	114		55.65	274.35
20	953833	502	2632	160214	FIRETOWE	1	31	3	36	4.1			28.5	31-1	79.9	7.5	3	80.1	113		55.7	279.61
21	953871	483	2632	160224	FIRETOWE	1	31	3	36	4.1			29.9	31-1	79	7.9	3	80.9	113		55.75	269.27
22	953782	458	2632	160201	FIRETOWE	1	31	3	37	4.3			30.3	31-1	79.8	7.7	3	79.3	114		55.8	255.56
23	953803	480	2632	160206	FIRETOWE	1	31	3	37	4.1			30.2	31-1	80.2	7.4	3	79.8	114		55.85	268.08
24	953853	467	2632	160219	FIRETOWE	1	31	3	36	4			30.6	31-1	78.5	8.2	3	81	111		55.95	261.29

Module #	Lf	Mic	Str	Rd	b	Tr	Unif	Loan Rat	Loan Value
1	3.00	3.95	30.03	78.40	8.10	3.00	79.65	55.33	268.64
2	3.00	4.28	30.83	78.90	7.80	3.25	80.28	55.90	276.38
3	2.75	4.15	29.95	79.70	7.73	2.50	79.90	55.95	272.69
4	3.00	3.95	30.78	78.63	7.83	2.75	79.75	55.88	274.35
5	2.75	4.28	29.35	80.20	7.20	3.00	80.55	56.05	281.98
6	3.00	4.10	30.00	80.03	7.50	2.50	80.68	56.05	278.38
7	3.00	4.13	30.60	78.60	8.00	3.50	79.95	55.68	269.30
8	2.75	3.95	30.43	78.35	8.03	2.75	80.13	55.94	263.61
9	3.00	4.17	31.43	78.47	7.93	3.33	80.13	56.05	274.86
10	3.00	4.17	30.07	78.40	8.17	3.33	79.87	55.68	277.31
11	2.75	4.20	30.28	78.78	8.05	3.00	80.23	55.93	272.22
12	3.00	4.27	28.83	80.13	7.30	3.00	80.97	56.03	274.75
13	2.75	4.10	30.85	79.95	7.68	3.00	80.78	56.48	269.71
14	2.75	4.08	29.63	80.10	7.48	2.75	80.35	55.98	272.18
15	3.00	4.28	30.48	79.80	7.45	3.50	80.88	56.31	284.81
16	3.00	3.95	30.28	80.03	7.60	2.50	80.40	56.34	272.24
17	3.00	3.90	31.60	78.43	8.05	3.00	80.53	56.38	262.97
18	2.75	4.23	29.25	80.08	7.13	3.25	81.50	56.38	287.80
19	3.00	4.08	29.98	79.85	7.40	2.50	81.08	56.39	280.12
20	3.00	4.18	29.80	79.68	7.48	2.75	81.00	56.36	284.82
21	3.00	4.20	29.50	80.08	7.30	2.75	81.40	56.33	280.51
22	3.00	4.08	30.35	79.43	7.73	3.00	80.60	56.34	276.61
23	2.25	4.03	31.28	78.00	8.13	2.25	79.80	56.40	280.31
24	3.00	4.05	30.93	79.33	7.68	3.00	81.28	56.54	276.76
25	3.00	4.20	31.40	78.75	7.98	2.75	81.03	56.55	282.61

Methodology for Uncertainty Analysis

- Adapted python code was written similar to module averaging
- An excel of standard deviation of fiber parameters for each module were created



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Methodology for Uncertainty Analysis

- Using the equation Std/$\sqrt{n}$
  - n = the number of bales per module
  - Typically four, but some module only produce three bales
- Uncertainty analysis is used to explain the variability of the module average due to the variability of the input fiber quality
- This was accomplished using an excel calculator
  - Referencing the standard deviation sheet created prior

Statistical Results

Standard Deviation of Fiber Quality Parameters by Module										
Module #	Lf	Mic	Str	Rd	b	Tr	Unif	Len	Loan Rat	Loan Value
1	0.50	0.22	1.00	0.54	0.10	0.82	1.12	1.71	0.60	10.13
2	0.50	0.06	0.74	0.53	0.17	0.50	1.05	2.89	0.48	4.29
3	0.50	0.10	0.28	0.45	0.26	0.50	0.79	1.83	0.11	4.11
4	0.50	0.17	1.20	0.41	0.23	0.82	0.93	3.42	0.66	10.01
5	0.50	0.06	1.29	0.57	0.25	0.58	0.98	2.45	0.79	11.51
6	0.50	0.05	0.98	0.22	0.10	0.50	1.01	1.26	0.13	4.60
7	0.00	0.06	0.65	0.25	0.12	0.58	0.61	0.82	0.25	3.08
8	0.00	0.06	0.38	0.50	0.15	0.00	0.67	2.63	0.02	11.63
9	0.00	0.10	1.21	0.13	0.05	0.00	0.24	2.16	0.17	6.04
10	0.00	0.06	1.56	0.50	0.22	0.00	0.76	2.22	0.78	7.06
11	0.00	0.08	1.17	0.33	0.06	0.00	0.45	0.96	0.24	9.40
12	0.00	0.06	0.63	0.17	0.13	0.50	1.20	1.71	0.51	3.82
13	0.00	0.05	1.07	0.34	0.08	0.58	0.94	1.15	0.18	8.95
14	0.00	0.08	1.79	0.10	0.08	0.58	1.09	2.36	0.73	2.90
15	0.00	0.13	0.78	0.24	0.13	0.58	1.08	0.82	0.25	7.54
16	0.00	0.00	0.90	0.25	0.14	0.50	0.77	1.50	0.14	9.68
17	0.50	0.05	0.87	0.21	0.10	0.96	0.59	0.82	0.33	5.91
18	0.00	0.05	1.01	0.55	0.41	0.50	0.76	2.22	0.24	16.64
19	0.50	0.14	0.77	0.25	0.10	0.82	0.71	2.06	0.19	7.90
20	0.00	0.08	0.26	0.17	0.17	0.50	1.06	1.00	0.04	6.09
21	0.00	0.10	0.80	0.39	0.34	0.50	0.41	4.50	0.76	2.50
22	0.00	0.06	0.74	0.83	0.17	0.00	0.93	3.21	0.33	4.03
23	0.00	0.06	0.40	0.26	0.06	0.58	0.55	1.00	0.25	3.30
24	0.00	0.05	0.51	0.41	0.08	0.58	0.97	0.96	0.36	4.57
25	0.00	0.06	0.76	0.25	0.06	0.58	0.60	2.08	0.56	8.83

If cell is highlighted, this means it is outside of range (-1.96 - 1.96)

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Statistical Results

Uncertainty Analysis of Fiber Quality Parameters by Module

Module #	Lf	Mic	Str	Rd	b	Tr	Unif	Len	Loan Rat	Loan Value
1	0.25	0.11	0.50	0.27	0.05	0.41	0.56	0.85	0.30	5.06
2	0.25							.44	0.24	2.15
3	0.25							.91	0.05	2.06
4	0.25							.71	0.33	5.00
5	0.25							.22	0.40	5.76
6	0.25							.63	0.06	2.30
7	0.00							.41	0.12	1.54
8	0.00							.31	0.01	5.81
9	0.00							.08	0.08	3.02
10	0.00							.11	0.39	3.53
11	0.00							.48	0.12	4.70
12	0.00							.85	0.26	1.91
13	0.00							.58	0.09	4.47
14	0.00							.18	0.36	1.45
15	0.00							.41	0.12	3.77
16	0.00							.75	0.07	4.84
17	0.25							.41	0.17	2.96
18	0.00							.11	0.12	8.32
19	0.25							.03	0.10	3.95
20	0.00							.50	0.02	3.04
21	0.00							.25	0.38	1.25
22	0.00							.86	0.19	2.33
23	0.00	0.03	0.23	0.15	0.03	0.33	0.32	0.58	0.15	1.91
24	0.00	0.03	0.25	0.20	0.04	0.29	0.49	0.48	0.18	2.28
25	0.00	0.03	0.44	0.15	0.03	0.33	0.35	1.20	0.32	5.10

Total Uncertainty by Fiber Parameter

Parameter	Average SD	Uncertainty
Lf	0.16	0.03
Mic	0.08	0.02
Str	0.87	0.17
Rd	0.35	0.07
b	0.15	0.03
Tr	0.48	0.10
Unif	0.81	0.16
Len	1.91	0.38
Loan Rat	0.36	0.07
Loan Value	6.98	1.40

So how does this mean for the John Deere HID project?

Averaged module quality, for most parameters, is a statistically acceptable metric to show the fiber quality of a cotton crop.

Future Plans

- This process of validating the effectiveness of module averaging will be done again on a total of 101 round modules from the 2021 season
- The ginning order of modules will be confirmed
  - Looking to see if there is any apparent correlation between modules

Conclusion

- Module averaging is still effective way to show the variability of fiber quality from bales produced from each module
  - For parameters such as length and loan value this may not be accurate
- For the John Deere HID project, module averaging can be used to display spatial variation of the different fiber quality parameter

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Questions?

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