MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 04-2018 (YEAR 1)
2018 ANNUAL REPORT

Title: Cover Crop – Minimal Tillage Production System Evaluation

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BACKGROUND & OBJECTIVES

Cover crops and minimal tillage (CCMT) production systems have seen increased adoption and interest in recent years. Identifying and understanding yield factors and relationships in high-yielding soybean production systems calls for an innovative approach to on-farm research. A systems agronomy approach was used to evaluate yield factors and relationships on six split field sites in the Mississippi Delta representing Commerce, Dundee, and Forestdale soil series. Each land-leveled and furrow-irrigated field was divided to implement a CCMT system on half of the field while the cooperating grower continued to farm the other half using their best management practices (Farmers Best Management – FBM). Project objectives are summarized as follows:

1) Implement a systems agronomy research approach to identify yield limiting/driving factors.
2) Assess insect, disease, and weed presence, and document threshold-based treatments.
3) Evaluate soil water characteristics to improve sensor placement and irrigation scheduling.
4) Assess *Rhizobia* and N fixation potential of soils to improve nitrogen management strategies in high-yielding soybean production systems.

KEY FINDINGS YEAR ONE

1. "Planting green" into cover crops significantly reduced yield. No significant difference in yield when covers terminated 4-6 weeks prior to planting.
2. Data suggest yield reductions may relate to stand establishment and early season growth.
3. No difference in threshold-based insect, disease, or weed prescriptions between CCMT and FBM.

Management Implications and Considerations

1. A two-pass herbicide program is recommended if terminating cover crops at planting. Apply a systemic herbicide application (e.g. glyphosate) at least 48 hours preplant, followed by a contact herbicide application (e.g. paraquat) plus any pre-emerge products at planting. This two-pass approach has been very successful in terminating tall and/or high biomass cover crops.
2. Cover crop residue management around the seed furrow should be considered when managing for a potential high yield crop. Residue in the seed trench can result in uneven emergence and yield potential loss in corn. "Shark Tooth" style row cleaners modified with a plate to cover 80% of the "tooth" has been the most effective option in moving residue with minimal wrapping observed to date.
3. High biomass cover crops may reduce both nutrient availability and soil temperature at planting. The use of an in-furrow starter fertilizer may improve stand establishment and early season development.

SUMMARY REPORT OF PROGRESS/ACTIVITY

Six split field sites meeting the criteria listed above were planted into a winter cover crop mix of cereal rye, black oats, hairy vetch, and winter pea. Cover crops were drilled into raised beds prepared in the fall of 2017 and subsequently planted into corn (3 fields) and soybean (3 fields). All fields were sampled/monitored through the 2018 growing season and harvested with spatially-referenced yield data successfully collected on 5 of the 6 farms.

The crop yield summary in **Table 1** below shows significant yield reductions when planting into a green cover crop (i.e. termination at planting). Early cover crop termination (4-6 weeks preplant) in corn did not result in a significant difference in yield, although the FBM treatment yielded slightly higher. Not presented in Table 1 are the results from the Dundee 1 field site where spatial yield data were not collected. However, scale tickets provided by the cooperating farmer indicate that the CCMT treatment yielded an average of 66 bu/acre while the FBM yielded 63 bu/acre.

Table 1. Crop yield summary by treatment.

Commerce 2 / Forestdale 1 - Planted Green			**Dundee 2 - Planted Green**		
Treatment	Yield (corn)	Std. Dev.	Treatment	Yield (soybean)	Std. Dev.
CCMT	210 b	16.1	CCMT	77 b	4.7
FBM	240 a	13.8	FBM	92 a	5.5
Commerce 1 - Early Termination			**Forestdale 2 - Planted Green**		
CCMT	209	13.8	CCMT	62 b	5.9
FBM	214	19.5	FBM	77 a	5.1

Objective 1 – Implement a Systems Agronomy research approach to identify yield factors.

Crop yield reductions in "planted green" scenarios were anticipated. The aim of Objective 1 was to identify factors contributing to these yield reductions in order to improve yield in subsequent years. Yield factor analysis in year one was based on fixed and spatially-referenced sampling points established on a 1-acre grid. Because of the high variability in alluvial soils, only planter and yield data falling within a radius equivalent to 1 header width (**Appendix Figure 1**) were used for analysis.

Point based analysis was utilized given the lack of confidence in uniform interpolation of soil test and plant tissue data outward from the sampling location. However, management zones (currently under development) will be utilized in year two for data interpolation and to conduct yield factor analysis at a much higher spatial resolution (38 x 38 ft grid). For the initial yield factor analysis, 138 measured data variables (e.g. soil, tissue, planter) were plotted against yield by field, farm, crop, and treatment scales resulting in over 2,750 scenarios. Data variables are listed and described in Appendix Table 1. Output from this analysis was ranked based on goodness of fit and variables that may help explain yield factors are summarized below.

Corn

1. Yield increased with % clean furrow when evaluated across treatments. However, CCMT fields planted green showed increased variability and decreasing yield with % clean furrow. We suspect this is due to lower cover crop biomass on the bottom of the fields (due to winter flooding), and the tendency for these portions of the field to be inherently lower yielding. This further supports the need for management zone development and use in analysis.

2. Yield increased with soil test and plant tissue phosphorous and potassium across treatments.

Soybeans

1. Seedling emergence and stand development delays were observed in both "planted green" scenarios. These early delays carried into the growing season with CCMT soybeans 10-14 days behind FBM soybeans in growth stage and maturity.
    a. Planting dates coincided with the beginning of a "dry spell" where no measurable rainfall occurred for approximately 2 weeks. Cover crop water use may have contributed to delayed emergence. Slugs were also an issue on the Dundee 2 CCMT field.
2. Within the Dundee 2 site data, no soil fertility interactions were observed between CCMT and FBM treatments.
    a. Across both treatments, sodium at 6-12 inches exhibited and negative relationship with yield. Positive relationships with yield were observed in plant tissue calcium, manganese, phosphorous, and sulfur.
3. Within the Forestdale 2 site data, no soil fertility interactions were observed between CCMT and FBM treatments.
    a. Across both treatments, positive relationships between soil test calcium, plant tissue calcium, plant tissue manganese, and yield were observed. Plant tissue phosphorus and copper exhibited a negative relationship with yield.

Unsupervised machine learning was also conducted to determine if multiple variables, or interactions among variables, could be considered as potential yield factors. Different combinations of independent variables resulted in 18 unique input datasets on which Principal Component and Self Organizing Map analyses were performed to identify clusters within the data. In summary, the data set (based on 242 sample locations across six farms) contained too much unaccounted-for variability (e.g. identification of historically poor yielding areas, low spots) for these methods to provide any meaningful results.

Conducting on-farm research is technically challenging but can provide relevant and applicable results when performed properly. In fulfilling Objective 1, on-farm research methodologies and approaches will be improved. Two areas of improvement slated for year two are summarized below.
1. Develop management zones using electrical conductivity (measured through Electromagnetic Induction), elevation, and yield stability analysis as base criteria.
2. Develop methodology for multivariate classification of farming systems.

Objective 2 – Assess insect, disease, and weed presence, and document threshold-based treatments.

Southern Ag consultants scouted trial fields weekly. Field records were documented and spatially referenced using tools developed through ArcGIS Online. No insect, disease, or weed issues specific to CCMT systems was observed.

Objective 3 – Evaluate soil water characteristics to improve sensor placement and irrigation scheduling.

Soil moisture probes were installed and operated on trial fields to support irrigation scheduling throughout the 2018 growing season. The probes installed were Sentek "Drill & Drop" probes in both 36" and 48" length which contain volumetric moisture sensors at 4-inch depth increments. 28 additional probes were installed post-harvest, operated through the winter, and pulled immediately pre-planting in

2019. These probes were installed at an approximate density of one per five acres on four farms, with a minimum of one probe placed in each mapped soil unit occurring in the field. Soil cores were planned for extraction and analysis during the fall/winter of 2018/19. However, wet field conditions since harvest have prevented this activity from taking place. Soil cores will be extracted for analysis as soon as field conditions allow.

Objective 4 – Assess *Rhizobia* and N fixation potential of soils to improve nitrogen management strategies in high-yielding soybean production systems.

Soil samples from corn and soybean sites were collected, the DNA extracted for 16S (bacteria) and 18S (fungi) rRNA, and queued for sequencing via Mississippi State University Soil Microbial Ecology & Metagenomics Lab. A group of N cycle taxa, which includes N-fixing *Rhizobia*, will be annotated using MG-RAST and the N fixation potential assessed by means of functional genomic analysis.

Appendix

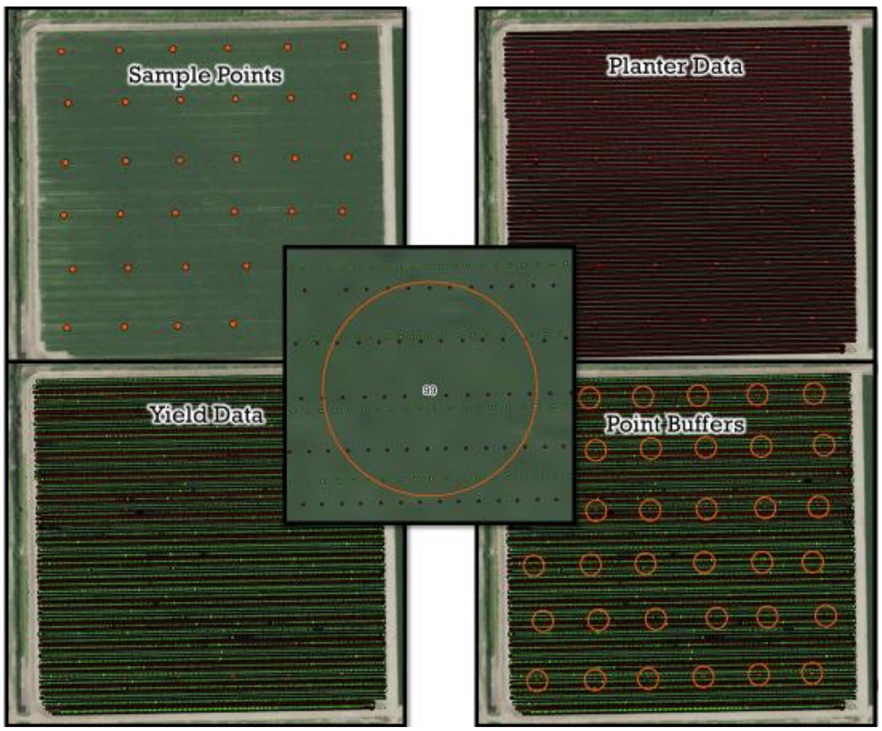


Figure 1 – Graphical display of methodology used to extract and average planter and yield data to fixed 1-acre grid sample points for data analysis. Only points within the circular buffers were included in the analysis dataset.

Table 2. Data variables used in yield factor analysis.

Code	Code	Description
B_06	B_612	Boron
Ca_06	Ca_612	Calcium
Cu_06	Cu_612	Copper
Fe_06	Fe_612	Iron
K_06	K_612	Potassium
Mg_06	Mg_612	Magnesium
Mn_06	Mn_612	Manganese
Na_06	Na_612	Sodium
P_06	P_612	Phosphorous
S_06	S_612	Sulfur
Zn_06	Zn_612	Zinc
BS_Ca_06	BS_Ca_612	Base Saturation Calcium
BS_H_06	BS_H_612	Base Saturation Hydrogen
BS_K_06	BS_K_612	Base Saturation Potassium
BS_Mg_06	BS_Mg_612	Base Saturation Magnesium
BS_Na_06	BS_Na_612	Base Saturation Sodium
BufferPH_0	BufferPH_6	Buffer pH
PH_06	PH_612	Soil pH
HMEQ_06	HMEQ_612	Hydrogen
CEC_06	CEC_612	Cation Exchange Capacity
OM_06	OM_612	Organic Matter
Ca_06_MSU	Ca_612_MSU	Calcium*
K_06_MSU	K_612_MSU	Potassium*
Mg_06_MSU	Mg_612_MSU	Magnesium*
Na_06_MSU	Na_612_MSU	Sodium*
P_06_MSU	P_612_MSU	Phosphorous*
Zn_06_MSU	Zn_612_MSU	Zinc*
PH_06_MSU	PH_612_MSU	Soil pH*
CEC_06_MSU	CEC_612_MSU	Cation Exchange Capacity*

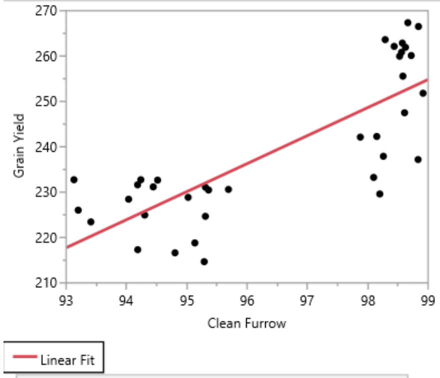
"06" notation = 0" to 6" sampling depth
"612" notation = 6" to 12" sampling depth
* denotes analysis at MSU soils lab

Code	Description
N_5_18	Nitrogen - May 18
S_5_18	Sulfur - May 18
P_5_18	Phosphorous - May 18
K_5_18	Potassium - May 18
Mg_5_18	Magnesium - May 18
Ca_5_18	Calcium - May 18
Na_5_18	Sodium - May 18
B_5_18	Boron - May 18
Zn_5_18	Zinc - May 18
Mn_5_18	Manganese - May 18
Fe_5_18	Iron - May 18
Cu_5_18	Copper - May 18
Al_5_18	Aluminum - May 18

Tissue samples collected for five consecutive weeks. Code for subsequent samples follows the same pattern. E.g. N_6_1 = Nitrogen June 1

Precision Planting	**Smart Firmer Sensor Readings**
Singulation	Organic Matter
Skips & Doubles	Furrow Moisture
Spacing & Speed	Furrow Uniformity
Ride & Ground Contact	Clean Furrow
DownForce & DownForce Margin	Soil Temp

Bivariate Fit of Grain Yield By Clean Furrow



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.792724	0.627653	0.889579	<.0001*
Covariance	26.88531			
Count	36			

Variable	Mean	Std Dev
Clean Furrow	96.50845	2.086354
Grain Yield	239.4463	16.25567

Linear Fit

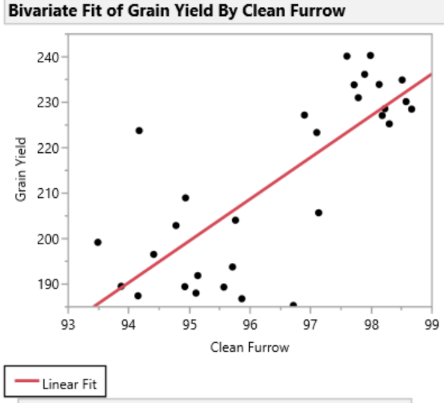
Grain Yield = -356.6333 + 6.1764496*Clean Furrow

Summary of Fit

RSquare	0.628412
RSquare Adj	0.617483
Root Mean Square Error	10.0538
Mean of Response	239.4463
Observations (or Sum Wgts)	36

Figure 2. Yield by % Clean Furrow on Commerce 2 site across CCMT & FBM treatments.

Bivariate Fit of Grain Yield By Clean Furrow



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.774163	0.573981	0.887032	<.0001*
Covariance	25.14543			
Count	30			

Variable	Mean	Std Dev
Clean Furrow	96.44159	1.655121
Grain Yield	212.7775	19.62443

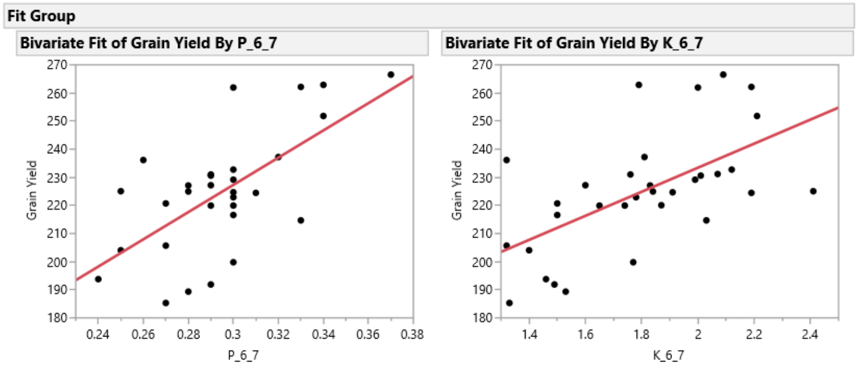
Linear Fit

Grain Yield = -672.4684 + 9.179088*Clean Furrow

Summary of Fit

RSquare	0.599328
RSquare Adj	0.585018
Root Mean Square Error	12.64187
Mean of Response	212.7775
Observations (or Sum Wgts)	30

Figure 3. Yield by % Clean Furrow on Forestdale 1 site across CCMT & FBM treatments.



Summary Statistics (Grain Yield By P_6_7)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.642976	0.379329	0.810054	<.0001*
Covariance	0.377993			
Count	32			

Variable	Mean	Std Dev
P_6_7	0.294688	0.027938
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 82.034988 + 484.26843*P_6_7

Summary of Fit

RSquare	0.413419
RSquare Adj	0.393866
Root Mean Square Error	16.38228
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Summary Statistics (Grain Yield By K_6_7)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.597037	0.313636	0.782771	0.0003*
Covariance	3.688074			
Count	32			

Variable	Mean	Std Dev
K_6_7	1.797188	0.293568
Grain Yield	221.2074	21.42308

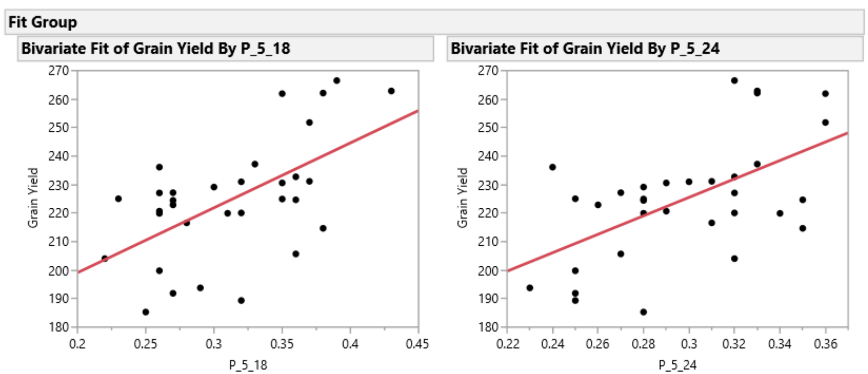
Linear Fit

Grain Yield = 147.8341 + 42.793943*K_6_7

Summary of Fit

RSquare	0.356453
RSquare Adj	0.335001
Root Mean Square Error	17.15933
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Figure 4. Corn yield and plant tissue P & K across all sites and treatments.



Summary Statistics (Grain Yield By P_5_18)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.579588	0.289377	0.772218	0.0005*
Covariance	0.653467			
Count	32			

Variable	Mean	Std Dev
P_5_18	0.3125	0.053581
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 153.61406 + 227.6121*P_5_18

Summary of Fit

RSquare	0.335922
RSquare Adj	0.313787
Root Mean Square Error	17.43089
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Summary Statistics (Grain Yield By P_5_24)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.570442	0.276807	0.766643	0.0007*
Covariance	0.444964			
Count	32			

Variable	Mean	Std Dev
P_5_24	0.2975	0.03707
Grain Yield	221.2074	21.42308

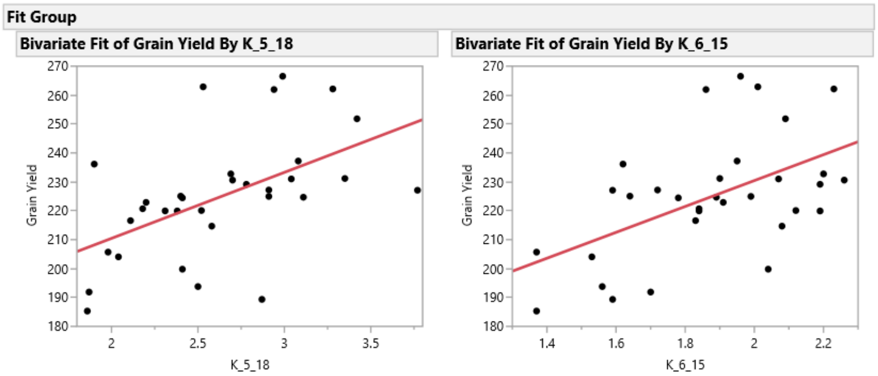
Linear Fit

Grain Yield = 128.41226 + 323.80028*P_5_24

Summary of Fit

RSquare	0.325404
RSquare Adj	0.302917
Root Mean Square Error	17.5684
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Figure 5. Corn yield and plant tissue P across all sites and treatments.



Bivariate Fit of Grain Yield By K_5_18

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.530742	0.223389	0.742098	0.0018*
Covariance	5.465261			
Count	32			

Variable	Mean	Std Dev
K_5_18	2.625625	0.48937
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 164.82336 + 22.821035*K_5_18

Summary of Fit

RSquare	0.281687
RSquare Adj	0.257743
Root Mean Square Error	18.12872
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Bivariate Fit of Grain Yield By K_6_15

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.529284	0.221463	0.741186	0.0018*
Covariance	2.76984			
Count	32			

Variable	Mean	Std Dev
K_6_15	1.8725	0.2487
Grain Yield	221.2074	21.42308

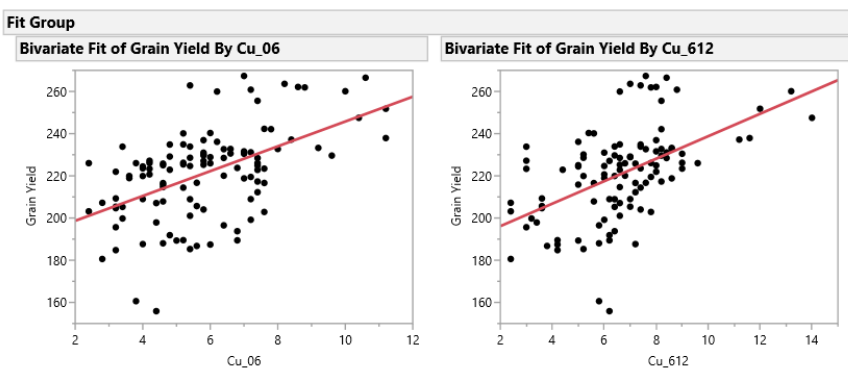
Linear Fit

Grain Yield = 140.88852 + 44.782011*K_6_15

Summary of Fit

RSquare	0.280142
RSquare Adj	0.256147
Root Mean Square Error	18.1482
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Figure 6. Corn yield and plant tissue K across all sites and treatments.



Bivariate Fit of Grain Yield By Cu_06

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.520347	0.372036	0.642751	<.0001*
Covariance	21.12034			
Count	114			

Variable	Mean	Std Dev
Cu_06	5.821053	1.894635
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 186.95817 + 5.8836898*Cu_06

Summary of Fit

RSquare	0.270761
RSquare Adj	0.26425
Root Mean Square Error	18.37583
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Bivariate Fit of Grain Yield By Cu_612

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.51691	0.367978	0.639983	<.0001*
Covariance	23.03201			
Count	114			

Variable	Mean	Std Dev
Cu_612	6.7	2.079866
Grain Yield	221.2074	21.42308

Linear Fit

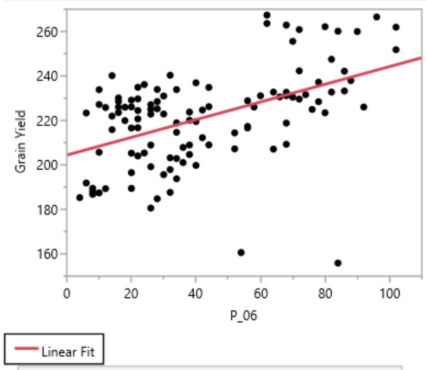
Grain Yield = 185.53472 + 5.3242855*Cu_612

Summary of Fit

RSquare	0.267196
RSquare Adj	0.260653
Root Mean Square Error	18.4207
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Figure 7. Corn yield and soil test copper across all sites and treatments.

Bivariate Fit of Grain Yield By P_06



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.484147	0.329579	0.61344	<.0001*
Covariance	270.328			
Count	114			

Variable	Mean	Std Dev
P_06	42.15789	26.06343
Grain Yield	221.2074	21.42308

Linear Fit

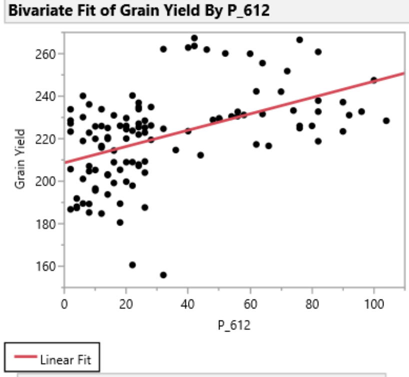
Grain Yield = 204.43072 + 0.3979495*P_06

Summary of Fit

RSquare	0.234399
RSquare Adj	0.227563
Root Mean Square Error	18.8284
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Figure 8. Corn yield and soil test P at 0-6 inches across all sites and treatments.

Bivariate Fit of Grain Yield By P_612



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.483478	0.3288	0.612895	<.0001*
Covariance	279.8587			
Count	114			

Variable	Mean	Std Dev
P_612	32.61404	27.01966
Grain Yield	221.2074	21.42308

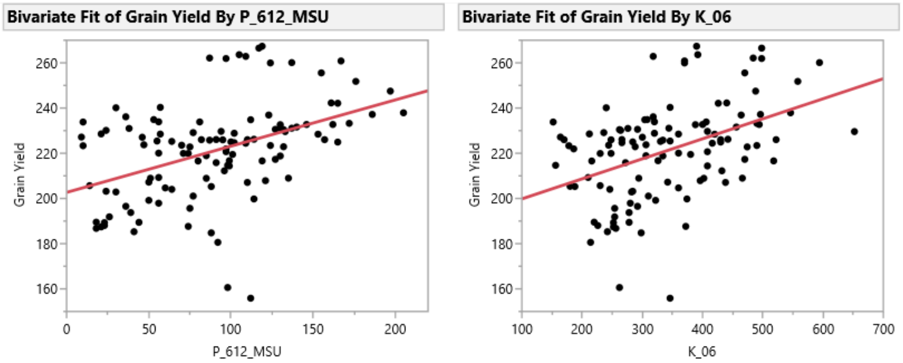
Linear Fit

Grain Yield = 208.70532 + 0.3833355*P_612

Summary of Fit

RSquare	0.233751
RSquare Adj	0.22691
Root Mean Square Error	18.83636
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Figure 9. Corn yield and soil test P at 6-12 inches across all sites and treatments.



Summary Statistics (P_612_MSU)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.437182	0.275412	0.574875	<.0001*
Covariance	428.8771			
Count	114			

Variable	Mean	Std Dev
P_612_MSU	90.39474	45.79188
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 202.71904 + 0.2045295*P_612_MSU

Summary of Fit

RSquare	0.191128
RSquare Adj	0.183906
Root Mean Square Error	19.35316
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Summary Statistics (K_06)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.433555	0.271271	0.571871	<.0001*
Covariance	973.741			
Count	114			

Variable	Mean	Std Dev
K_06	341.1579	104.8376
Grain Yield	221.2074	21.42308

Linear Fit

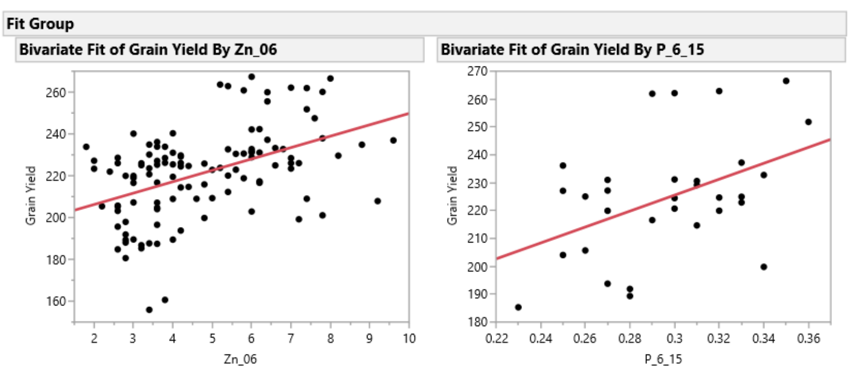
Grain Yield = 190.98257 + 0.088595*K_06

Summary of Fit

RSquare	0.18797
RSquare Adj	0.18072
Root Mean Square Error	19.39091
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Figure 10. Corn yield and soil test P & K across all sites and treatments.

Fit Group



Summary Statistics (Zn_06)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.459854	0.301432	0.593568	<.0001*
Covariance	17.81002			
Count	114			

Variable	Mean	Std Dev
Zn_06	4.74386	1.807851
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 195.35681 + 5.4492803*Zn_06

Summary of Fit

RSquare	0.211466
RSquare Adj	0.204425
Root Mean Square Error	19.10832
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Summary Statistics (P_6_15)

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.449029	0.118961	0.689729	0.0099*
Covariance	0.312207			
Count	32			

Variable	Mean	Std Dev
P_6_15	0.297188	0.033043
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 139.7629 + 285.94722*P_6_15

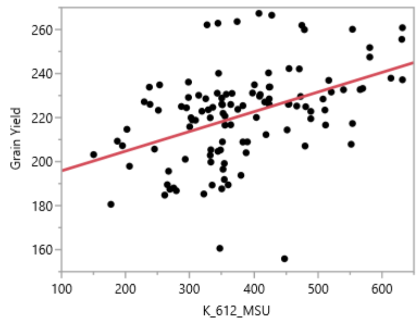
Summary of Fit

RSquare	0.201627
RSquare Adj	0.175015
Root Mean Square Error	19.11231
Mean of Response	224.7428
Observations (or Sum Wgts)	32

Figure 11. Corn yield and soil test Zn & plant tissue P across all sites and treatments.

Fit Group

Bivariate Fit of Grain Yield By K_612_MSU



Linear Fit

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.444881	0.284221	0.581238	<.0001*
Covariance	1016.22			
Count	114			

Variable	Mean	Std Dev
K_612_MSU	383.6491	106.6258
Grain Yield	221.2074	21.42308

Linear Fit

Grain Yield = 186.91508 + 0.0893847*K_612_MSU

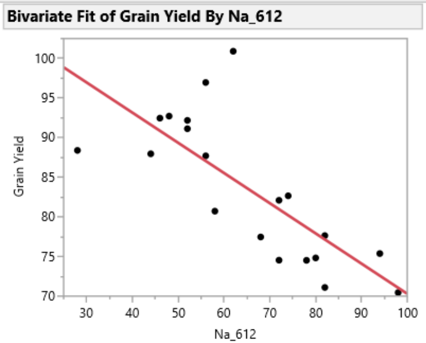
Summary of Fit

RSquare	0.197919
RSquare Adj	0.190757
Root Mean Square Error	19.27176
Mean of Response	221.2074
Observations (or Sum Wgts)	114

Figure 12. Corn yield and soil test K across all sites and treatments.

Fit Group

Bivariate Fit of Grain Yield By Na_612



Linear Fit

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	-0.75602	-0.89808	-0.47111	0.0001*
Covariance	-122.482			
Count	20			

Variable	Mean	Std Dev
Na_612	65.1	17.92939
Grain Yield	83.59384	9.03601

Linear Fit

Grain Yield = 108.39795 - 0.3810155*Na_612

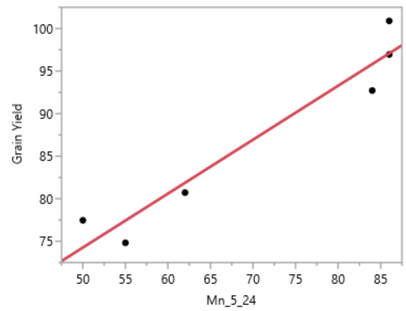
Summary of Fit

RSquare	0.571562
RSquare Adj	0.54776
Root Mean Square Error	6.07661
Mean of Response	83.59384
Observations (or Sum Wgts)	20

Figure 13. Soybean yield and soil test Na on Dundee 2 site across CCMT & FBM treatments.

Fit Group

Bivariate Fit of Grain Yield By Mn_5_24



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.964072	0.700889	0.996202	0.0019*
Covariance	176.9082			
Count	6			

Variable	Mean	Std Dev
Mn_5_24	70.5	16.70629
Grain Yield	83.59384	9.03601

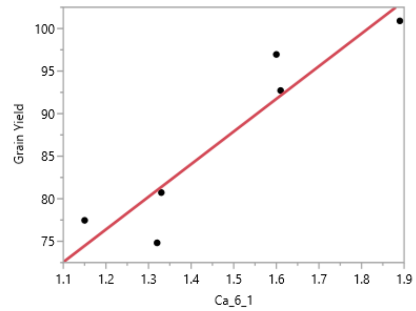
Linear Fit

Grain Yield = 42.58269 + 0.6338525*Mn_5_24

Summary of Fit

RSquare	0.929435
RSquare Adj	0.911794
Root Mean Square Error	3.262177
Mean of Response	87.26929
Observations (or Sum Wgts)	6

Bivariate Fit of Grain Yield By Ca_6_1



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.932257	0.495842	0.992733	0.0067*
Covariance	2.733616			
Count	6			

Variable	Mean	Std Dev
Ca_6_1	1.483333	0.266958
Grain Yield	83.59384	9.03601

Linear Fit

Grain Yield = 30.372227 + 38.357569*Ca_6_1

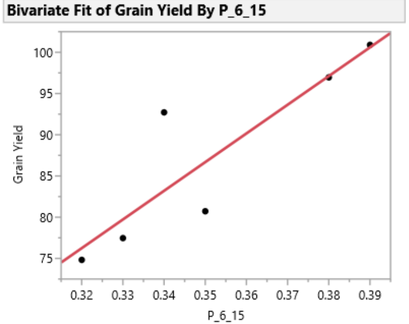
Summary of Fit

RSquare	0.869104
RSquare Adj	0.836379
Root Mean Square Error	4.443012
Mean of Response	87.26929
Observations (or Sum Wgts)	6

Figure 14. Soybean yield and plant tissue Mn & Ca on Dundee 2 site across CCMT & FBM treatments.

Fit Group

Bivariate Fit of Grain Yield By P_6_15



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.882676	0.25071	0.987119	0.0198*
Covariance	0.270195			
Count	6			

Variable	Mean	Std Dev
P_6_15	0.351667	0.027869
Grain Yield	83.59384	9.03601

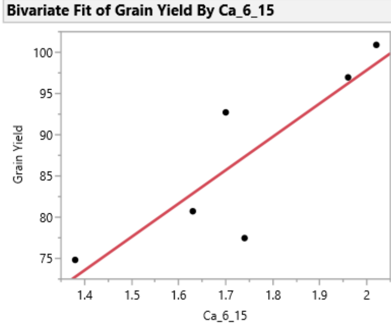
Linear Fit

Grain Yield = -35.07221 + 347.8905*P_6_15

Summary of Fit

RSquare	0.779117
RSquare Adj	0.723896
Root Mean Square Error	5.771578
Mean of Response	87.26929
Observations (or Sum Wgts)	6

Bivariate Fit of Grain Yield By Ca_6_15



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.856401	0.147027	0.984036	0.0295*
Covariance	2.18625			
Count	6			

Variable	Mean	Std Dev
Ca_6_15	1.738333	0.232415
Grain Yield	83.59384	9.03601

Linear Fit

Grain Yield = 16.912652 + 40.473616*Ca_6_15

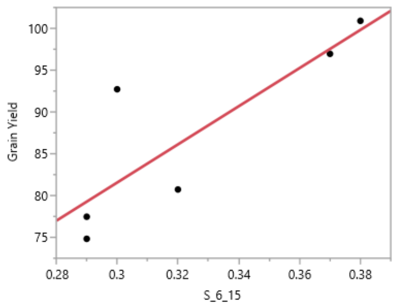
Summary of Fit

RSquare	0.733423
RSquare Adj	0.666779
Root Mean Square Error	6.340516
Mean of Response	87.26929
Observations (or Sum Wgts)	6

Figure 15. Soybean yield and plant tissue P & Ca on Dundee 2 site across CCMT & FBM treatments.

Fit Group

Bivariate Fit of Grain Yield By S_6_15



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.83933	0.087093	0.981991	0.0366*
Covariance	0.372207			
Count	6			

Variable	Mean	Std Dev
S_6_15	0.325	0.040373
Grain Yield	83.59384	9.03601

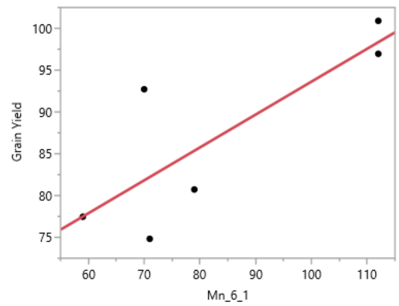
Linear Fit

Grain Yield = 13.056185 + 228.34801*S_6_15

Summary of Fit

RSquare	0.704474
RSquare Adj	0.630593
Root Mean Square Error	6.675924
Mean of Response	87.26929
Observations (or Sum Wgts)	6

Bivariate Fit of Grain Yield By Mn_6_1



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.814221	0.00784	0.978921	0.0486*
Covariance	203.2656			
Count	6			

Variable	Mean	Std Dev
Mn_6_1	83.83333	22.7281
Grain Yield	83.59384	9.03601

Linear Fit

Grain Yield = 54.281418 + 0.3934935*Mn_6_1

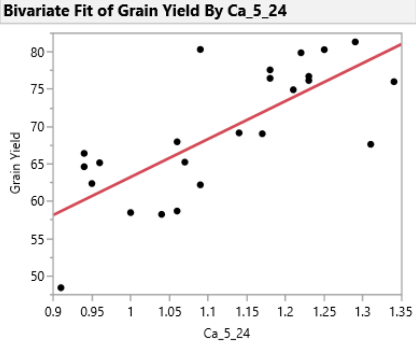
Summary of Fit

RSquare	0.662956
RSquare Adj	0.578694
Root Mean Square Error	7.129468
Mean of Response	87.26929
Observations (or Sum Wgts)	6

Figure 16. Soybean yield and plant tissue S & Mn on Dundee 2 site across CCMT & FBM treatments.

Fit Group

Bivariate Fit of Grain Yield By Ca_5_24



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.747593	0.492818	0.884304	<.0001*
Covariance	0.83706			
Count	24			

Variable	Mean	Std Dev
Ca_5_24	1.119167	0.128263
Grain Yield	69.51067	9.077264

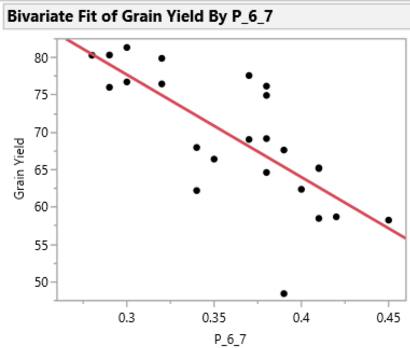
Linear Fit

Grain Yield = 12.376429 + 50.880596*Ca_5_24

Summary of Fit

RSquare	0.558895
RSquare Adj	0.538844
Root Mean Square Error	5.928066
Mean of Response	69.3203
Observations (or Sum Wgts)	24

Bivariate Fit of Grain Yield By P_6_7



Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	-0.74503	-0.88304	-0.48842	<.0001*
Covariance	-0.30883			
Count	24			

Variable	Mean	Std Dev
P_6_7	0.36125	0.047486
Grain Yield	69.51067	9.077264

Linear Fit

Grain Yield = 118.79769 - 136.96165*P_6_7

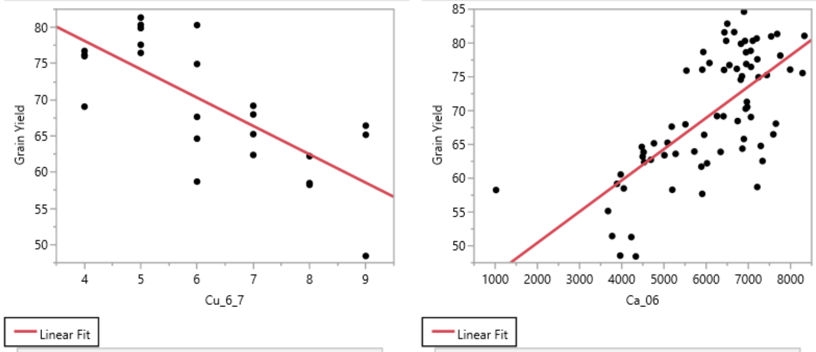
Summary of Fit

RSquare	0.555066
RSquare Adj	0.534842
Root Mean Square Error	5.953734
Mean of Response	69.3203
Observations (or Sum Wgts)	24

Figure 17. Soybean yield and plant tissue Ca & P on Forestdale 2 site across CCMT & FBM treatments.

Fit Group

Bivariate Fit of Grain Yield By Cu_6_7 | **Bivariate Fit of Grain Yield By Ca_06**



Bivariate Fit of Grain Yield By Cu_6_7

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	-0.73947	-0.88028	-0.47894	<.0001*
Covariance	-10.6411			
Count	24			

Variable	Mean	Std Dev
Cu_6_7	6.25	1.648451
Grain Yield	69.51067	9.077264

Linear Fit

Grain Yield = 93.79479 - 3.915919*Cu_6_7

Summary of Fit

RSquare	0.546816
RSquare Adj	0.526216
Root Mean Square Error	6.008683
Mean of Response	69.3203
Observations (or Sum Wgts)	24

Bivariate Fit of Grain Yield By Ca_06

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.688748	0.543858	0.793763	<.0001*
Covariance	8458.538			
Count	72			

Variable	Mean	Std Dev
Ca_06	6124.111	1352.944
Grain Yield	69.51067	9.077264

Linear Fit

Grain Yield = 41.211187 + 0.004621*Ca_06

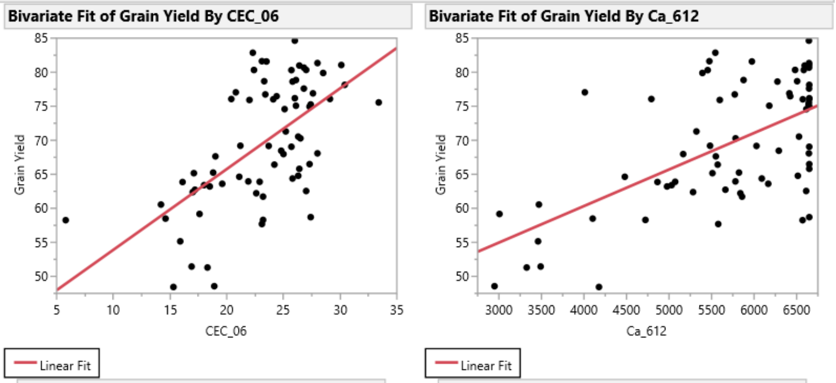
Summary of Fit

RSquare	0.474374
RSquare Adj	0.466865
Root Mean Square Error	6.627864
Mean of Response	69.51067
Observations (or Sum Wgts)	72

Figure 18. Soybean yield and plant tissue Cu & soil test Ca on Forestdale 2 site across CCMT & FBM treatments.

Fit Group

Bivariate Fit of Grain Yield By CEC_06 | **Bivariate Fit of Grain Yield By Ca_612**



Bivariate Fit of Grain Yield By CEC_06

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.612345	0.443607	0.739156	<.0001*
Covariance	26.027			
Count	72			

Variable	Mean	Std Dev
CEC_06	23.15139	4.682451
Grain Yield	69.51067	9.077264

Linear Fit

Grain Yield = 42.028271 + 1.1870735*CEC_06

Summary of Fit

RSquare	0.374966
RSquare Adj	0.366037
Root Mean Square Error	7.227481
Mean of Response	69.51067
Observations (or Sum Wgts)	72

Bivariate Fit of Grain Yield By Ca_612

Summary Statistics

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	0.602853	0.43144	0.732253	<.0001*
Covariance	5574.911			
Count	72			

Variable	Mean	Std Dev
Ca_612	5708.194	1018.76
Grain Yield	69.51067	9.077264

Linear Fit

Grain Yield = 38.849184 + 0.0053715*Ca_612

Summary of Fit

RSquare	0.363431
RSquare Adj	0.354338
Root Mean Square Error	7.293866
Mean of Response	69.51067
Observations (or Sum Wgts)	72

Figure 19. Soybean yield and soil test CEC & Ca on Forestdale 2 site across CCMT & FBM treatments.

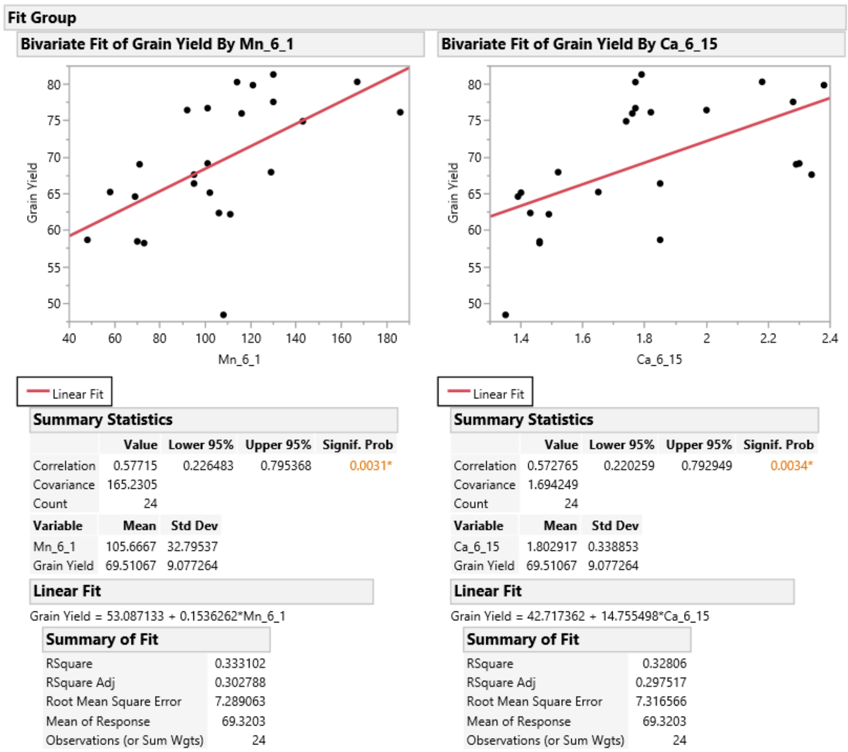


Figure 20. Soybean yield and plant tissue Mn & Ca on Forestdale 2 site across CCMT & FBM treatments.