Impact of Spatial Soil Variability on Maize Yield in Eastern Kansas River Basin

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Introduction

Weather and soil play an important role in crop production. Soil variability helps to determine crop performance, especially in rainfed agriculture. Eastern Kansas has a favorable climate for growing maize under rainfed conditions. This study quantified the variation in maize yield due to the spatial distribution of soils. For this study, the cropping system model CERES-Maize of Decision Support System for Agrotechnology Transfer (DSSAT) used to simulate long term historic yield.

Objective

- To calibrate the DSSAT model for assessing the impact of spatial soil variability on maize yield
- Mapping the yield variation to identify the maize growing areas in the Eastern Kansas River Basin (EKSRB).

Data

Soils data: Soil Survey Geographic database (SSURGO) soils data

Observed maize yield: USDA NASS (20 years)

Climate data: GRIDMET (University of Idaho Gridded Surface Meteorological Dataset)

Counties: Atchison and Brown

Crop models: DSSAT v4.8- CERES Maize

Mapping: ArcGIS-10.8

Methodology

- The cropping system model CERES-Maize of Decision Support System for Agrotechnology Transfer (DSSAT) was calibrated using the observed yield of rainfed maize from the historic National Agricultural Statistical Service (NASS). The model was calibrated based on soil fertility factor (SLPF), and Genotype Coefficient Calculator (GENCALC) was used to calibrate five genetic cultivar coefficients for maize.
- DSSAT seasonal analysis was run for each county under the rainfed condition to simulate the maize yield for 17 counties from 2000-2019. SSURGO soil datasets were used as input in the DSSAT model for simulating the growth, development, and yields of maize for each county.
- The performance of the model was evaluated using statistical analysis, including RMSE and d-stat value.
- ArcGIS 10.8 (ESRI, 2020) was used to create maize yield maps for each county. Crop data layer (CDL) (NASS, 2019) data for Atchison and Brown counties in Kansas were downloaded, and the SSURGO spatial soil data layer was then clipped to the maize growing areas in each county. The yield maps were then created by assigning yield values obtained by running DSSAT for each of the soils present in each county.

Results

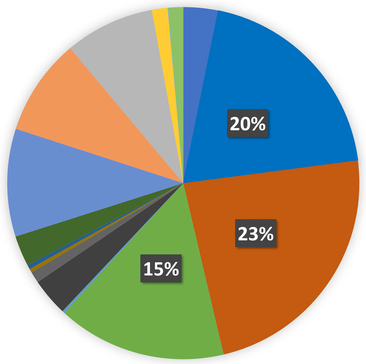

Figure 1: Prominent soils in Atchison County(Kennebec silt loam (23%), Muscotah silty clay loam (20%), and Reading silt loam (15%)

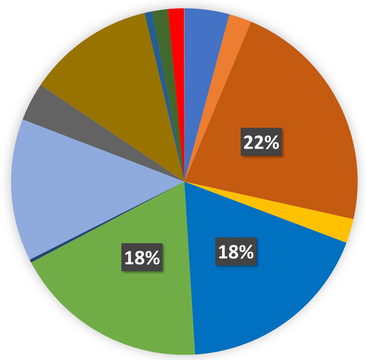

Figure 2: Prominent soils in Brown County(Kennebec silt loam (22%), Muscotah silty clay loam (18%), and Reading silt loam (18%)

Table 1. Soil fertility factor (SLPF), root mean square error (RMSE); and index of agreement (d-stat) between average simulated and observed maize yield for 20 years (2000-2019)

Location	SLPF	Obs yield (kg/ha)	Simul yield (kg/ha)	RMSE	d-stat
Atchison	**.90**	8445	**9534**	1412	.84
Brown	**1.0**	9867	**10012**	1054	.89

- The difference between observed and simulated yield was below 16% in Atchison county and 2% in Brown county

Table 2. Calibrated cultivar coefficients for CSM-CERES-Maize for two counties

Parameter	Min	Max	Initial Value	Unit	Hybrid IB1066 PIO 3489	
					Atchison	Brown
P1	5.0	450.0	225.0	Deg Days	**180.00**	**120.0**
P2	0.0	2.0	0.600	Day/h	0.600	0.600
P5	580.0	990.0	895.0	Deg Days	895.0	895.0
G2	248.0	990.0	875.0	Kernel/plt	875.0	875.0
G3	5.0	16.50	8.80	Mg/day	8.80	8.80
PHINT	38.0	75.00	48.0	Deg Days	**55.44**	**55.44**

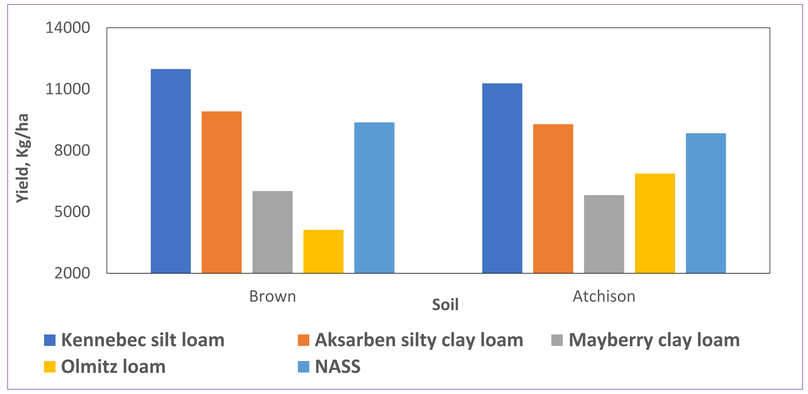

Figure 3: Comparison of NASS observed yield with simulated maize yields by DSSAT for different types of soil in Brown and Atchison County

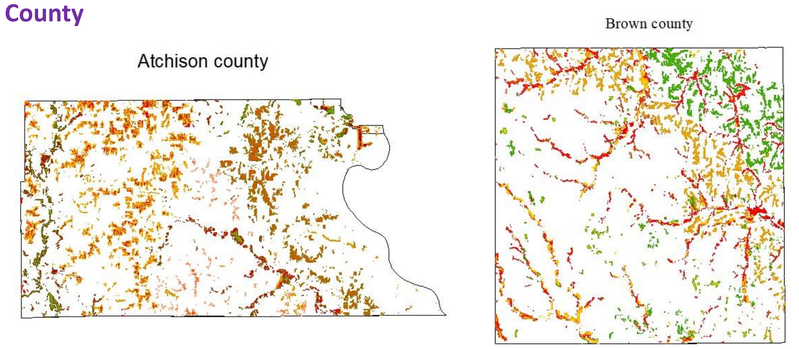

Figure 3: Variation of maize yield due to spatially distribution of soils (Green color showed the higher maize yield and the red color for the lower yield. The white color in each county represented that area is not suitable for growing maize)

Conclusions

- The DSSAT model simulated yield always higher compared to NASS observed yield because the DSSAT CERES model did not consider the insect, diseases and weed pressure on it.
- In Atchison county the higher yield observed as 11987 Kg/ha (Kennebec silt loam) and lower yield was 6023 Kg/ha (Mayberry clay loam). For Brown county, the higher yield was 11288 Kg/ha (Kennebec silt loam) and lower yield was 5822 Kg/ha (Olmitz loam).

Future goal

The study will contribute to find out the suitable maize growing area in the EKSRB region under future climate scenarios.

References

Jones, J. W., Hoogenboom, G., Boote, K. J., Porter, C. H. (n.d.). DSSAT v4.5 Cropping System Model Documentation, *4*, 450.

Sharda, V., Handyside, C., Chaves, B., McNider, R. T., Hoogenboom, G. (2017). The Impact of Spatial Soil Variability on Simulation of Regional Maize Yield. *Transactions of the ASABE*, *60*(6), 2137–2148. https://doi.org/10.13031/trans.12374

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