Spatio-Temporal Modeling and Forecasting of Corn Yield

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Introduction

Crop yield is a function of crops genetics, environment and their interaction. Genetics refers to variation in crops makeup that can be explained by the type of species or type of hybrid (varieties) within a species. Environment on the other hand refers to crop management, climate, soil, elevation and similar conditions that affect crop growth and final yield.

Since yield is function of environment and genetics, modeling and forecasting yield is possible with knowledge of the relationships between yield and components of these variables.

An accurate crop yield model can then be used for forecast which in turn enables better decision on crop selection, soil and crop management, marketing, storage, transport, and assessing risk associated with these activities.

Objectives

- To determine the distribution of dryland and irrigated corn yield
- To determine the variation in corn yield that can be explained by genetics, environment, and their interaction
- To investigate the relationship between yield and selected environmental variables, and
- To develop an optimum model that accurately forecast corn yield

Materials and Methods

• The source of corn yield and crop management data was Kansas Corn Hybrid Performance Trials (KCPT) report.
• About 3581 dryland and 2795 Irrigated corn yield data were assembled from KCPT reports.
• Dryland corn yield and management data was from KCPT reports in the years 1992-2009 while irrigated corn yield and management data was from KCPT reports in the years 2002-2009 from 9 counties in Kansas (Fig. 1).
• There were about 1293 hybrids in drylands and 756 corn hybrids in irrigated tests in the time and space the data was assembled.
• County climate data source was K-state weather data library.

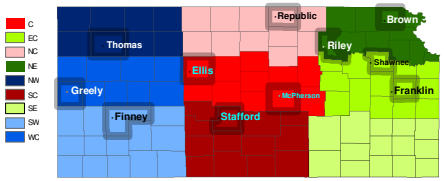

Figure 1. Map of Kansas depicting counties and their district where the Kansas Corn Hybrid Performance Trials data for the years 1992-2009 was assembled from.

• Maps were created in arcmap of ArcGIS software
• Models are tested, fitted, selected in SAS software
• Data smooth line fitting and other graphics are made in R

Acknowledgment

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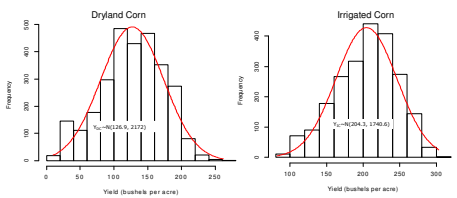
KANSAS STATE UNIVERSITY

Results and Discussion

Dryland and Irrigated Corn Yield Distribution



Y_{DC}=126.9± 46.6 Y_{IC} =204.3 ±41.7

Figure 2. Distribution of dryland and irrigated corn yields in Kansas from performance trial data

Yield = μ ± σ → Partitioning σ → Yield =μ ±σ_e ±σ_g ±σ_{eg}

Statistics		Dryland Corn	Irrigated Corn
% of the deviation explained by	Environment (E)	93.0	77.5
	Genetics (G)	1.0	10.5
	G by E	6.0	12.0

Environment : Space and Time

What comes with environment (space and time) that directly influence yield?

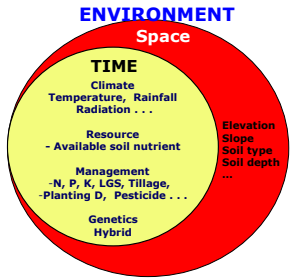


Figure 3. Space-time model depicting Major environmental factors that vary in space, time or in space and time and have a direct influence on crop yield.

Dryland Corn Yield as Function of Rainfall

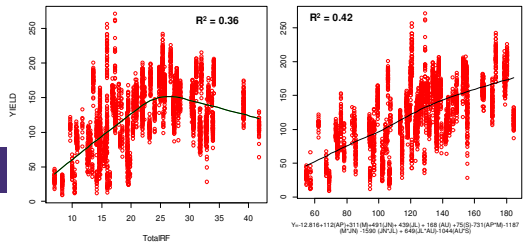


Figure 4. Relationship between dryland corn yield and total APR to SEP rainfall in inches (left) and relationship between yield and daily average monthly rainfall with interaction of consecutive monthly rainfall events (right).

Dryland Corn Yield as a Function of Temperature

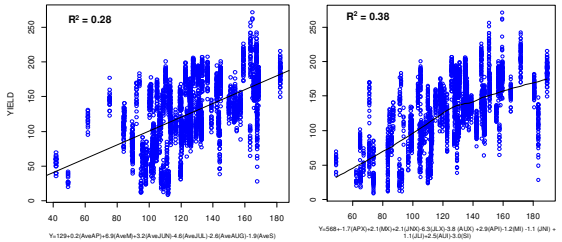


Figure 5. Relationship between dryland corn yield and average monthly APR to SEP temperature (left) and relationship between yield and daily average monthly maximum and minimum temperatures (right).

Dryland Corn Yield as a Function of Management

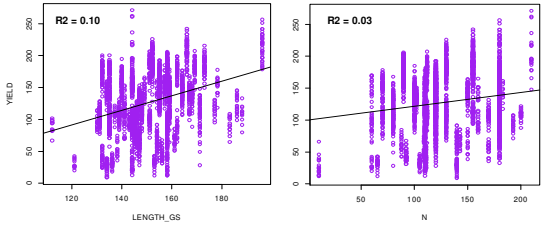
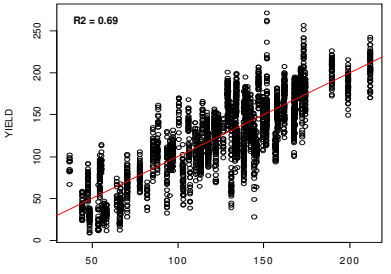


Figure 6. Relationship between dryland corn yield and length of growing season (left) and amount of nitrogen fertilizer applied (right).

Modeling Dryland Corn Yield with Major Factors and Space-time Adjustment



YIELD as function of

LENGTH_GS + N + Aprtmax + Maytmax + Juntmx + Jultmax +Augtmax + Septmax + Aprtmin + Maytmin + Juntmin +Jultmin + Augtmiin + Septmin + AprilRF + MayRF + JunRF +JulRF + AugRF + SepRF + **county+ lustrum**

lustrum = period of five year

Figure 7. Yield as function of management and climate with space-time adjustment

Conclusion

- Corn yield is approximately normally distributed.
- About 93% of the variability in dryland corn yield is due to environmental variations.
- Including each and every environmental factors and their possible interactions in a model is usually impossible. A space and time adjustment along with important factors resulted in a reasonable model.