Spring wheat yields on two contrasting aridic agriborolls in northcentral Montana
by Brian David Schweitzer

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Soil Science
Montana State University

Abstract:
Spring wheat yield data were collected on two soils of north-central Montana. The soils are Scobey and Kevin series which are both Aridic Argiborolls. These soils occur in complexes on glacial till in northern Montana. Soil plots were identified within single fields allowing examination of the soils yield performance independent of other variables such as management and climate.

Wheat grown on Scobey plots always outyielded wheat on Kevin plots. Average yield on Scobey was 262 percent of average yield on Kevin. Wheat on Scobey plots yielded an average of 4653 kg/ha and wheat on Kevin averaged 1772 kg/ha.

Wheat on the two soils utilized nearly the same quantity of water. Available P, NO3-N, CaCO3 ($p = .01$); organic matter, and extractable K ($p = .05$) were correlated with soil series. Water is usually considered to be the most yield limiting factor in Montana dryland wheat production, but in this study, yield differences between soil series ;were due to soil fertility rather than soil water.

Soil yield performance data collection procedures of this study could be adapted by the Soil Conservation Service. These procedures would be more accurate and useful than the data collection system presently used.

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Date July 10, 1980

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ABSTRACT

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INTRODUCTION

There is a need for detailed soil performance data. A producer cannot choose a realistic level of management inputs unless the expected yield is known. A reasonable yield goal can only be estimated by soil performance studies under known management and climatic conditions. Results of such studies can assist 1) farmers in management decisions, 2) land use planners in feasibility studies, and 3) private and public agencies in land appraisal.

The Soil Conservation Service (SCS) presently provides yield predictions in published soil survey reports. The soil survey manual (Soil Survey Staff, 1951) states that "performance judgments are based upon evidence afforded by actual yield data from sample areas of the soil mapping units", but this approach is seldom utilized.

The most useful performance data includes yield predictions for a given soil under a wide range of management and climate. For example, on a given soil, a producer could predict crop yields based upon specific management practices and climate. This information allows accurate cost/benefit predictions prior to planting.

OBJECTIVES

Objectives of this study were: 1) to collect actual field yield data from Scobey and Kevin soils, and 2) to determine the significance of these soils to crop yield by comparing spring wheat yields on two soils within one field. Management and macroclimate are nearly identical. Therefore, the yield difference must be due to soil.

REVIEW OF LITERATURE

The art of soil classification and mapping is at least 4,000 years old (Thorp, 1935). During this century, it became apparent that the mere classification of a soil does not sufficiently aid the resource manager. The next logical step was to provide recommendations about potential uses of soils for engineering and edaphological purposes. Presently, the SCS provides this information in all published soil surveys.

One of the most important applications of soil surveys is the prediction of crop yields from particular soil units. Predicted yields can help producers set realistic yield goals and link productivity to land evaluation (Soil Survey Staff, 1951).

Presently yield predictions are compiled in three manners: 1) interviews with producers and visual field observations, 2) examination of farm records, and 3) actual yield determination from sample areas of the soil unit (Odell, 1958). The last technique is the most accurate, but is seldom employed.

Yield data collection has been studied for many years. Soybeans, winter wheat, oats and corn yields were examined on Clinton Silt Loam for seven years. This central Illinois (Rust & Odell, 1957) study included records from several farms under a wide range of management. Another Illinois study employed multiple curvilinear regression analysis of crop yields on soil units under varied management and climatic conditions. The study included data from seven hundred farm production records. The length of the production records varied from five to twenty-five years. The crop yields on each soil unit increased or decreased from year to year, up to fifty-six percent (Rust & Odell, 1957).

In one study (Henao, 1976), soil productivity ratings were based upon over thirty physical and chemical properties. The intent was to examine such factors as: percent carbon in the plow layer, plant available water holding capacity of the soil profile, bulk density in the subsoil horizons, pH by horizon, depth to the top of the calcium carbonate horizon, and assign numerical yield values contributed by each factor. Another report (deJong and Rennie, 1967) concluded, "it is impossible to assess the practical significance of specific soil physical properties in terms of wheat production on the basis of current research information."

A model was designed in Oklahoma (Allgood and Gray, 1977) to assign soil productivity ratings for yield prediction on different soils. They tried two systems. The first utilized laboratory data, field observations and published yield information. The second system was based solely on diagnostic soil characteristics included in *Soil Taxonomy*. Water was the most yield limiting factor in this study. Parameters that affected soil moisture such as slope, clay percent, and percent organic matter were most important in predicting yield.

There are three basic components of yield soil, climate and management. Yield prediction accuracy suffers when any of these independent components is not accurately identified or held constant. To overcome this problem, some workers have compared yields on different soil units within individual fields. This approach holds management and microclimate constant so yield differences are attributed to soil alone (Ferguson & Gorby, 1966; Rennie & Clayton, 1960; Spratt & McIver, 1971). They demonstrated that yields can vary substantially, as much as 300 percent, between soils on glacial till catenas of the northern great plains when other variables are held constant. Furthermore, these investigations demonstrated that each soil responded differently to fertilizer treatments.

METHODS

Spring wheat was planted by five cooperating farm operators during May, 1979. Plots were identified and marked after the crop was seeded, but prior to germination. There were two plots per site, one on Scobey soils and one on Kevin, both within one field. Each plot measured 1.55m x 7.63m. Four farms had one site per field (1, 2, 3, 7) and one farm had three sites in one field (4, 5, 6) as can be seen in Figure 1 and legal descriptions of sites are in Table 1. Soil series chosen for this study occur on glacial till in northern Montana. The Scobey series (Figure 2) is identified as the most extensively cultivated soil in Montana (Genter, 1977). The Kevin soil series is found in complexes with the Scobey. They are both Aridic Argiborolls (Appendix IV). The Scobey is in the fine, montmorillonitic and Kevin is in the fine loamy, mixed family. Kevin contains $CaCO_3$ in the plow layer and Scobey does not.

Scobey and Kevin soils were formed on the same parent material. The differences between the two soils in the study are a result of geologic wind and water erosion moving material from the erosional or Kevin landscape positions to the depositional or Scobey positions. Due to its landscape position, these Scobey soils are deeper, more fertile and have a higher available water holding capacity than Kevin soils.

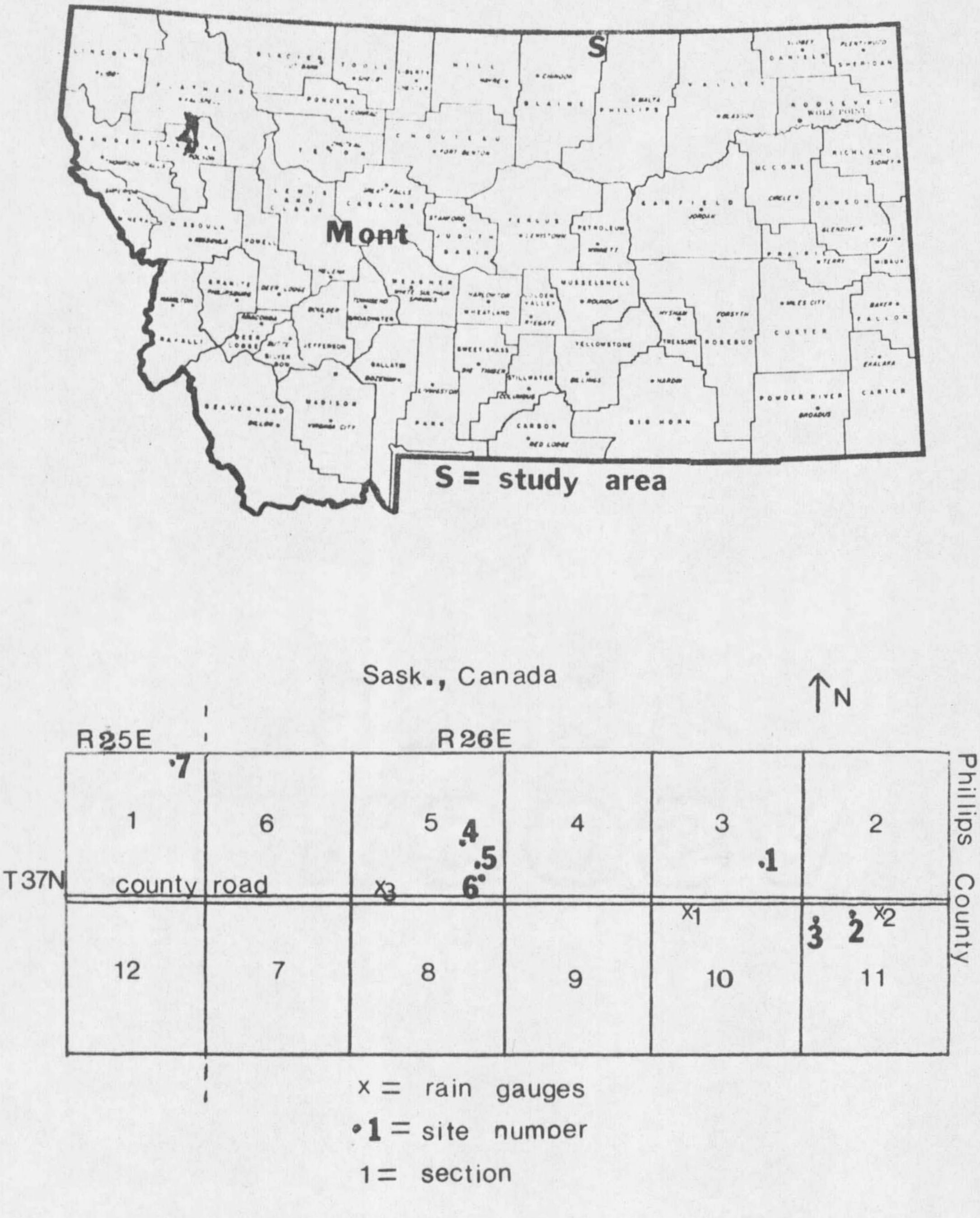

Figure 1. Location of Sites.

TABLE 1. QUESTIONNAIRE SUMMARY

Plot	Farm Operator	Legal Description	Seed Variety	Total Initial Water in 120cm Profile	Rainfall During Growing Season cm	Previous Crop	Summer Fallowed on Previous Year	Number of Times Tilled Prior to Planting	Stand Establishment 1 = Excellent 5 = Poor	Estimated Crop Loss Due to Weeds kg/ha	Planting Date 1979
1 S*	Walter Fouts	SE¼, NW¼, SE¼, Sec. 3 T 37N, R 26E	Bounty 309	19.8	13.04	Fallow	Yes	5	1	0	May 21
K*	Walter Fouts	SE¼, NW¼, SE¼, Sec. 3 T 37N, R 26E	Bounty 309	4.2	13.04	Fallow	Yes	5	1	0	May 21
2 S	Glenn Hutton	NW¼, NE¼, NW¼, Sec. 11 T 37N, R 26E	Bounty 309	9.3	12.37	Fallow	Yes	3	2	67	May 24
K	Glenn Hutton	NW¼, NE¼, NW¼, Sec. 11 T 37N, R 26E	Bounty 309	6.9	12.37	Fallow	Yes	3	2	67	May 24
3 S	Rick Glabofski	NW¼, NW¼, NW¼, Sec. 11 T 37N, R 26E	Bounty 309	6.1	12.37	Fallow	Yes	5	4	134	May 20
K	Rick Glabofski	NW¼, NW¼, NW¼, Sec. 11 T 37N, R 26E	Bounty 309	8.7	12.37	Fallow	Yes	5	4	134	May 20
4 S	Allen Billmyer	NE¼, NW¼, SE¼, Sec. 5 T 37N, R 26E	Butte	8.5	13.30	Fallow	Yes	4	2	33	May 26
K	Allen Billmyer	NE¼, NW¼, SE¼, Sec. 5 T 37N, R 26E	Butte	11.0	13.30	Fallow	Yes	4	2	134	May 26
5 S	Allen Billmyer	SW¼, NE¼, SE¼, Sec. 5 T 37N, R 26E	Butte	10.6	13.30	Fallow	Yes	4	2	67	May 26
K	Allen Billmyer	SW¼, NE¼, SE¼, Sec. 5 T 37N, R 26E	Butte	9.7	13.30	Fallow	Yes	4	2	33	May 26
6 S	Allen Billmyer	NW¼, SE¼, SE¼, Sec. 5 T 37N, R 26E	Butte	9.0	13.30	Fallow	Yes	4	2	67	May 26
K	Allen Billmyer	NW¼, SE¼, SE¼, Sec. 5 T 37N, R 26E	Butte	8.2	13.30	Fallow	Yes	4	2	67	May 26
7 S	Sid Egbert	NE¼, NW¼, NE¼, Sec. 1 T 37N, R 25E	Prodax	6.8	13.30	Crested Wheat Grass	No	5	4	33	May 29
K	Sid Egbert	NE¼, NW¼, NE¼, Sec. 1 T 37N, R 25E	Prodax	1.28	13.30	Crested Wheat Grass	No	5	4	33	May 29

*S = Scobey
K = Kevin