Approved March 15, 1990
Date

MINUTES OF THE HOUSE COMMITTEE ON ENERGY AND NATURAL RESOURCES.

The meeting was called to order by Representative Dennis Spaniol at
Chairperson

3:30 ~~a.m.~~/p.m. on March 14, 1990 in room 526-S of the Capitol.

All members were present except:
Representative Lucas
Representative Webb

Committee staff present:
Raney Gilliland, Principal Analyst, Legislative Research
Mary Torrence, Revisor of Statutes' Office
Pat Mah, Legislative Research
Maggie French, Committee Secretary

Conferees appearing before the committee:
Mr. James A. Power, Jr., P.E., Director, Division of Environment, Kansas Department of Health and Environment
Mr. Wayne Bossert, Northwest Kansas Groundwater Management District No. 4, Colby, Kansas
Mr. Patrick Craig, Assistant Manager/Hydrogeologist, Southwest Kansas Groundwater Management District No. 3, Garden City, Kansas
Mr. Keith Lebbin, Manager, Western Kansas Groundwater Management District No. 1, Scott City, Kansas
Dr. Stephen E. White, Head of the Geology Department, Kansas State University
Mr. Hyde Jacobs, Director, Kansas Water Resources Research Institute, Kansas State University

Chairman Dennis Spaniol called the meeting to order.

Mr. James A. Power, Jr., P.E., Director, Division of Environment, Kansas Department of Health and Environment, was recognized by the chair and presented testimony on water quality of Ogallala formation outlining the methods and reviewing the results of data collection (Attachment 1). Discussion followed regarding nitrates in drinking water; whether or not fertilizer is a source of nitrate contamination and comparisons between nitrates found in well water and in stream water.

The chairman introduced Mr. Wayne Bossert, Northwest Kansas Groundwater Management District No. 4, Colby, Kansas, who testified regarding the powers and authorities; regulations and policies; current and developing programs of the Northwest Kansas Groundwater Management Districts (Attachment 2). Following his testimony inquiries from the committee concerned the groundwater districts working with the State of Kansas on the water plan; grant money from the plan to the districts; possible restrictions by groundwater district boards; adding of State Conservation Commission to the Water Authority; problems relative to water supplies for industries which may lower water tables and recharging of the Ogallala Aquifer. In response to a question from the chairman, Mr. Bossert stated recharge occurs when rainfall is above normal.

Mr. Patrick Craig, Assistant Manager/Hydrogeologist, Southwest Kansas Groundwater Management District No. 3, Garden City, Kansas, was recognized by the chair. He testified regarding research and education on the conservation and efficient use of water, water quality protection and water appropriation rights (Attachment 3). Discussion by the committee included amount of funds budgeted for groundwater districts; annual declines in water levels in Southwest Kansas; water wells being dug in the Dakota Aquifer; difference in quality of water in the Ogallala and Dakota aquifers and wells in Southwest Kansas Groundwater Management District No. 3 pumping from more than one aquifer.

CONTINUATION SHEET

MINUTES OF THE HOUSE COMMITTEE ON ENERGY AND NATURAL RESOURCES,

room 526-S Statehouse, at 3:30 xxxx p.m. on March 14, 1990

Mr. Keith Lebbin, Manager, Western Kansas Groundwater Management District No. 1, Scott City, Kansas, was called on by Chairman Spaniol and presented testimony on weather modification program and other programs of Western Kansas Groundwater Management District No. 1 (Attachment 4). Discussion followed on costs to purchase water rights in the district.

Chairman Spaniol welcomed Dr. Stephen E. White, head of the Geology Department, Kansas State University, who discussed research activities regarding aquifer maintenance and summarized facts and other information in his brochure concerning conservation of water in the High Plains (Attachments 5 and 6). Discussion by the committee related to how the survey was performed.

The chairman recognized Mr. Hyde Jacobs, Director, Kansas Water Resources Research Institute, Kansas State University, who testified regarding selected research pertinent to irrigation in the Ogallala Aquifer area in Western Kansas, citing two instances where water use has been studied (Attachment 7). In addition, the committee was provided with publications reporting on 1989 field day and 1989 agricultural research (Attachments 8 and 9). Discussion following included questions about the fairness of well spacing and government programs making larger payments for higher yields on crops.

Meeting adjourned at 5:13 p.m.

The next meeting of the committee will be at 3:30 p.m., March 15, 1990.

Date: 3-14-90

GUEST REGISTER

HOUSE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

NAME	ORGANIZATION	ADDRESS	PHONE
Rich McKee	KLA	Topeka	273-5115
Joyce Wolf	Ks. Audubon Council	Lawrence	749-3203
E R Moses	KAPA	Topeka	235-1188
Charlene Stinard	Ks Natural Resource Council	Topeka	233-6707
Bill Fuller	Kansas Farm Bureau	Manhattan	587-6110
Gary Hulett	Governor's Office	Topeka	296-6240
Beverly Steinmeyer	KDA	Topeka	
David L. Pope	DWR, KSBA	Topeka	296-3717
Keith Lebbin	Western Ks. Groundwater Dist. #1	Scott City, KS	(316) 872-5563
Patrick A. Craig	Southwest Ks. GMD #3	Garden City	(316) 275-7147
Tom McClain	Kansas Geol. Survey	Lawrence	913-864-3965
Robert W Buddemeier	KGS	Lawrence	" "
Stephen E White	Kansas State Univ (Geography)	Manhattan	913-532-6727
Hyde Jacobs	KSU	Manhattan	913-532-5739
WAYNE BOSSERT	NW KS GMD #4	P.O. Box 905, COLBY	462-3915
Wayland Anderson	KSBA DWR	Topeka, KS	296-3718
Tom Stiles	KWO	Topeka, KS	296-3185

AGENDA

House Energy and Natural Resources

March 13 and 14

Informational Meetings on the High Plains Aquifer (Ogallala)

March 13

3:30 p.m.--Lee Gerhard, Kansas Geological Survey--Review of status of aquifer

4:00 p.m.--David Pope, Division of Water Resources--Application of state law to the conservation of aquifer resources

4:30 p.m.--Bill Bryson, State Corporation Commission--Corporation Commission efforts to protect the aquifer

5:00 p.m.--Jim Power, Kansas Department of Health and Environment--Department's efforts in assessing water quality

March 14

3:30 p.m.--Wayne Bossert, Northwest Kansas Groundwater Management District No. 4, Colby--Review of role of GMD in conservation of aquifer

Patrick Craig, Southwest Kansas GMD No. 3, Garden City

Keith Lebbin, Western Kansas GMD No. 1, Scott City

4:15 --Steve White, Head of the Geography Department, Kansas State University--Research activities regarding aquifer maintenance

Hyde Jacobs, Assistant to the Dean of the College of Agriculture

State of Kansas
Mike Hayden, Governor

Department of Health and Environment
Division of Environment
Forbes Field, Bldg. 740, Topeka, KS 66620-0002

Stanley C. Grant, Ph.D., Secretary

(913) 296-1535
FAX (913) 296-6247

Testimony Presented to the

House Energy and Natural Resource Committee

on

Water Quality of Ogallala Formation

The quality of groundwater refers to its chemical, physical, and biological characteristics such as temperature, taste, and odor. Natural quality of groundwater depends upon its environment, movement, and source, and may well differ within the same aquifer.

Generally, the downward movement of water or pollutants from the ground surface through the soils to the groundwater table is measured in feet per day in contrast to the very slow horizontal movement once it becomes part of the groundwater aquifer. In both the downward and lateral movement, the chemical composition of the water or pollutant can be radically changed. The movement of poor quality groundwater to higher quality groundwater is influenced by the relative hydrostatic pressures on the two systems. Man's influence on these systems have, are and will, crate problems unless the geohydrology and geochemistry are fully understood.

The Basic Data Activity

Water quality data are collected from a network of wells to determine the chemical characteristics of groundwater in the principal aquifers. The chemical quality data evaluated determines the adequacy of the network for describing the baseline groundwater quality, detects pollution of the principal aquifer in the state, and determines the significance of the data in respect to state and federal water quality standards imposed by the Safe Drinking Water Act.

Data were obtained at 625 wells in the statewide water quality network or roughly about six wells per county.

H Energy and NR
3-14-90
Attachment 1

Charles Konigsberg, Jr., M.D., M.P.H., Director of Health (913) 296-1343

James Power, P.E., Director of Environment (913) 296-1535

Lorne Phillips, Ph.D., Director of Information Systems (913) 296-1415

Roger Carlson, Ph.D., Director of the Kansas Health and Environmental Laboratory (913) 296-1619

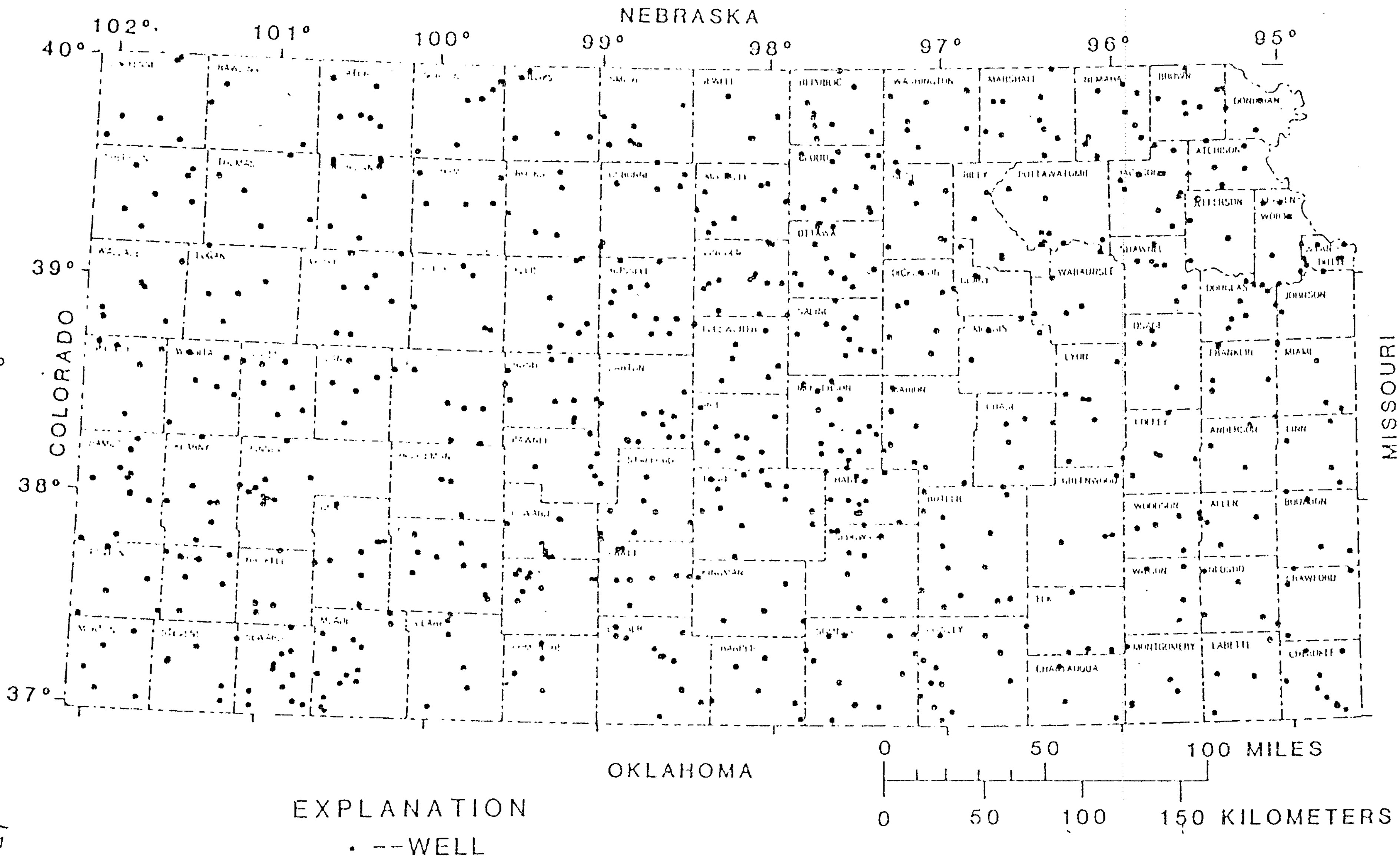


Figure 1.--Location of wells in Kansas Ground-Water-Quality Monitoring Network, 1976-81.

Data determined at these sites includes water temperature, specific conductance, pH, and inorganic constituents. Organic constituents also are determined at selected sites. During the period of 1976-80, 1,669 chemical analyses were made; 736 samples were tested for metals and 106 samples were examined for total organic carbon, pesticides and radiochemicals. This is a cooperative program between KDHE and the USGS. (Figure 1)

Each year the 525 water supplies dependent on groundwater as a source of supply have a laboratory chemical analysis of a sample taken from the distribution system and every three years the water is tested for presence of heavy metals. This sampling has been done for many years and is an important part of the statewide monitoring network.

The Kansas Geological Survey water investigations, in cooperation with the U.S. Geological Survey, have focused on groundwater. Present research is directed to assessment of major groundwater systems. development of predictive quantitative and qualitative groundwater models, geophysical and geochemical investigations, saline systems, acquisition and management of groundwater data systems, and problems such as liquid waste disposal, hydrological effects of mining, and economics of groundwater and energy.

One study of significance to the plan was undertaken by the KGS in 1973 when the Survey began a large-scale groundwater sampling program. It was designed as a one-shot program to establish a baseline condition. In the future, the baseline condition could be used to determine if special or area wide investigations might be necessary.

In west central Kansas (Groundwater Management District No. 1), studies revealed most Ogallala groundwater available for agricultural and domestic use to be of moderately good quality with a medium salinity hazard and low alkali hazard. Tests in southwest Kansas (Groundwater Management District No. 3) showed most areas have moderately good quality water with medium salinity hazards and low alkali hazards. In the Great Bend Prairie area (Groundwater Management District No. 5), potential for severe salinity problem is present in much of the eastern half of the district. Investigations in northwest Kansas (Groundwater Management District No. 4) showed most areas have moderately good quality water with medium salinity hazards and low alkali hazards, although water associated with alluvial stream systems frequently have high salinity hazards.

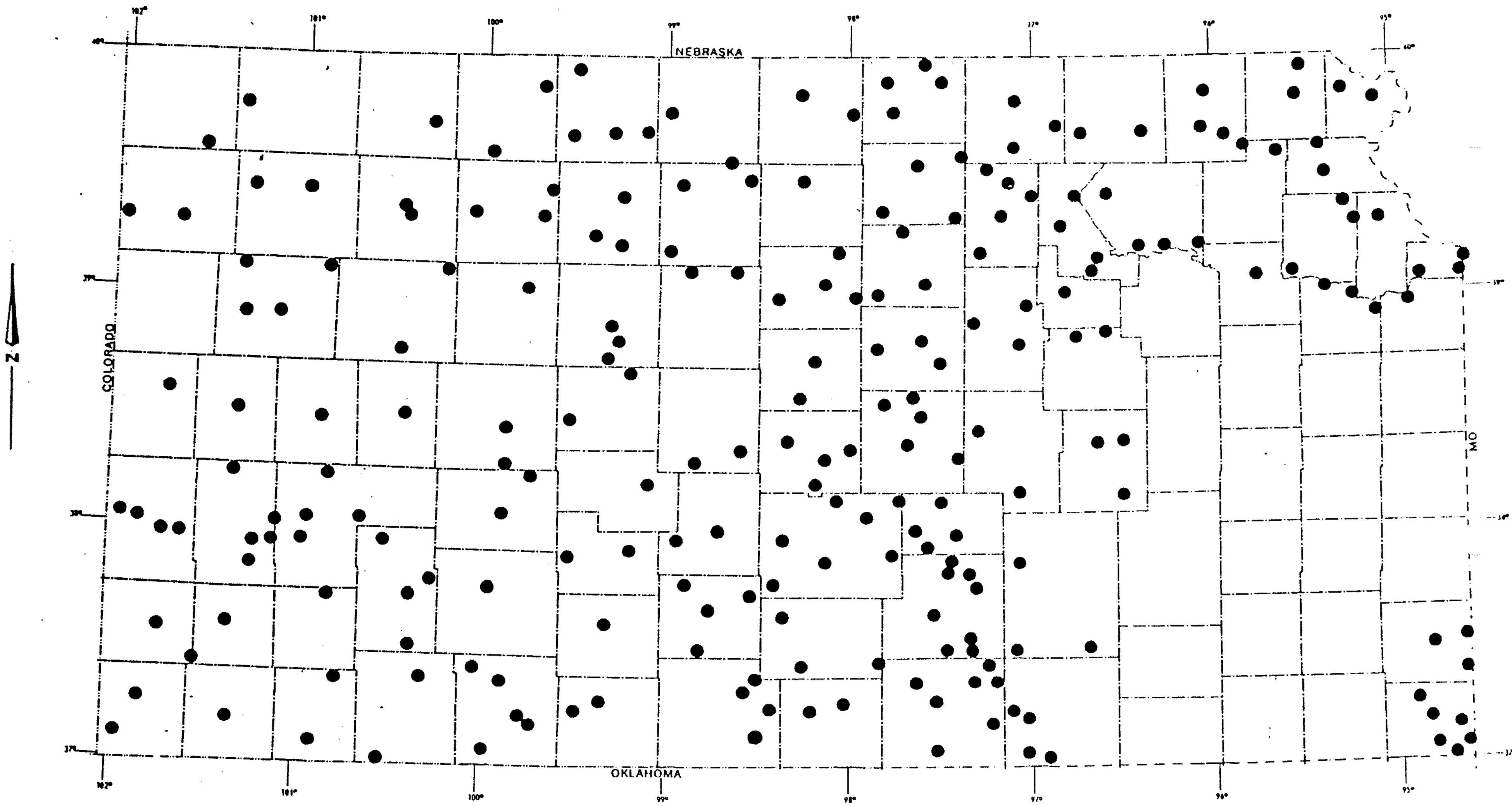
Since 1981 due to costs and other factors, the estimate of groundwater quality sampling has been restricted. Figure 2 shows the location of current sampling sites used by the department. Staff have reviewed data collected since the publication of the report on contaminants found in groundwater supplies in 1983. There has not been significant change in the water quality in the

Ogallala area. Nonetheless, this does not mean that we have not observed or investigated isolated instances of groundwater contamination. Members of this committee received a department report entitled "1989 Summary of Environmental Remediation Sites in Kansas." This report noted a number of sites identified by the department in our northwest and southwest districts are shown on Figures 3 and 4. In addition, Figure 5 notes the number of leaking underground storage tanks sites investigated each have resulted in contamination of groundwater. It could be noted from the maps of the Ogallala formation in these two KDHE districts, most of the contamination of groundwater is along the eastern line of the aquifer rather than the Ogallala.

Presented by: James A. Power, Jr., P.E.
Director, Division of Environment
Kansas Department of Health and Environment

Date: March 13, 1990

GROUNDWATER QUALITY SAMPLING SITES



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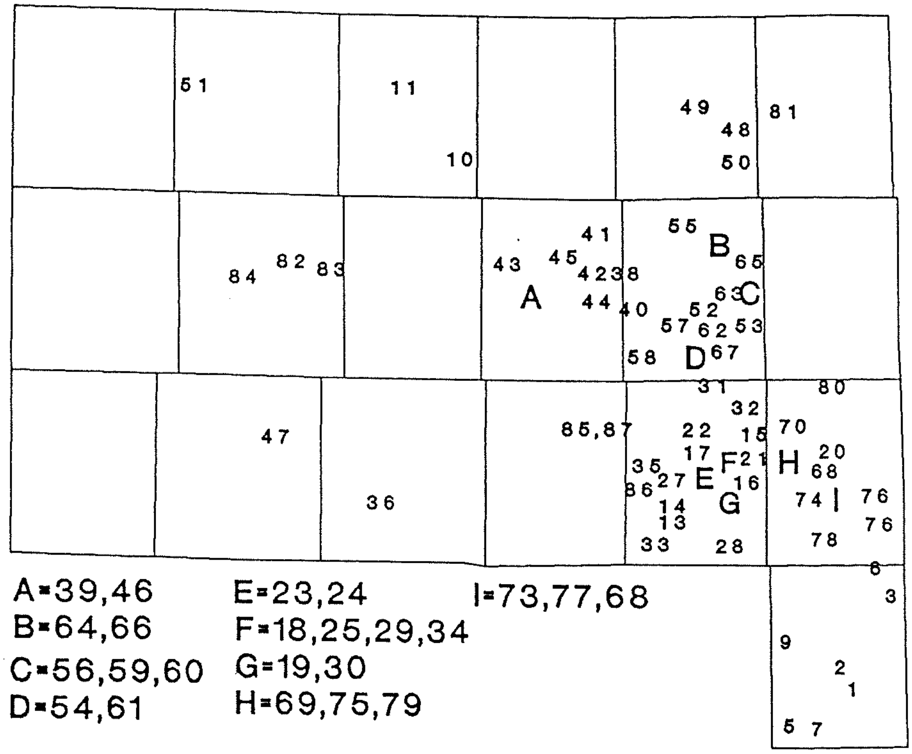
Northwest District



1 Dresser Industries
2 Great Bend Chloride Prob *
3 Harry Bumeister **

5 Pawnee Rock Salt Plant
6 Henry Staudinger
7 Larry Weathers **

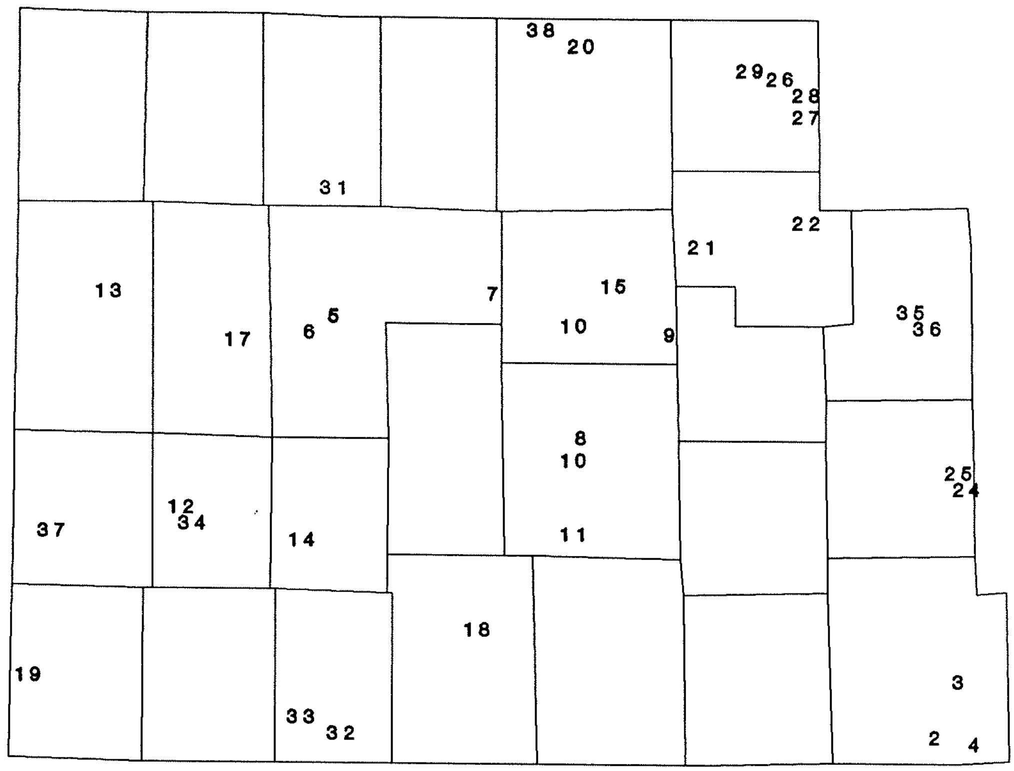
9 City of Albert *
10 City of Jennings **
11 Paul Bremer *
12 Marion Mockry
13 Andrew Wasinger *
14 Antonino Water Supply *
15 Dortland
16 Cecilia Dreiling
17 Cross Manufacturing Co.
18 Doris Lang **
19 Doug Phillip *
20 Ellis County Feeders
21 Fell Oil and Gas *
22 Frank Werth *
23 Hays Wells 20, 27, 28
24 Permian Oil
25 Jim Dinkel *
26 Jim Maxwell *
27 John Krause *
28 Leo Stramel*
29 Leon Dinkel, Tony Sanders *
30 Marcellus Gross **
31 Matador Pipeline
32 Nielson Sinkhole **
33 R. J. Zimmerman *
34 Catherine Haschenberger Townsite
35 Clarence Schaefer
36 Plum Creek Area

38 Bogue Area **
39 Fred Keith *
40 Gil Balthazor, Ray Brault *
41 Graham County Unknown *
42 Leon Fink **
43 E.L. Richmeier **
44 Wilbur Stites
45 Royal Acid
46 Harry Clint Minium **
47 Harry Unruh
48 Agra PWS Wells #3, #4
49 CRA, Inc. (Farmland Industries)
50 Kirwin Coop
51 City of McDonald
52 Carl Hilgens *
53 Codell, KS Area *
54 Foster Shepard
55 Griebel, Foster, Roy *
56 Laton Area - Several Landowners *
57 Mary Marcotte *
58 Mervin Keller *
59 Orville Garver *
60 Pat Irey - Hrabe Area *
61 Peavey-Mowry-Vine-Bates *
62 Plainville PWS #1
63 Scattered Rooks County *
64 Schruben *
65 Harold Simons
66 Stockton *
67 Tom Houser *
68 Dennis Dumler *
69 Everett Dortland **
70 Fairport Station

72 Keir *
73 Leland Nuss *
74 Les Wittman *
75 Louis Sander
76 Okmar Oil Company *
77 Russell RWD #1 **
78 Tittle Lease *
79 Trapp Oil Company *
80 Vernon Shaffer *
81 Kensington PWS Well #1
82 Ace Services, Inc.
83 High Plains Chemical Co. (Schmitt Brothers)
84 Wyrill Well
85 Deggs, Braun-Caroll Wynn
86 Frank Schneller
87 Al Dreiling

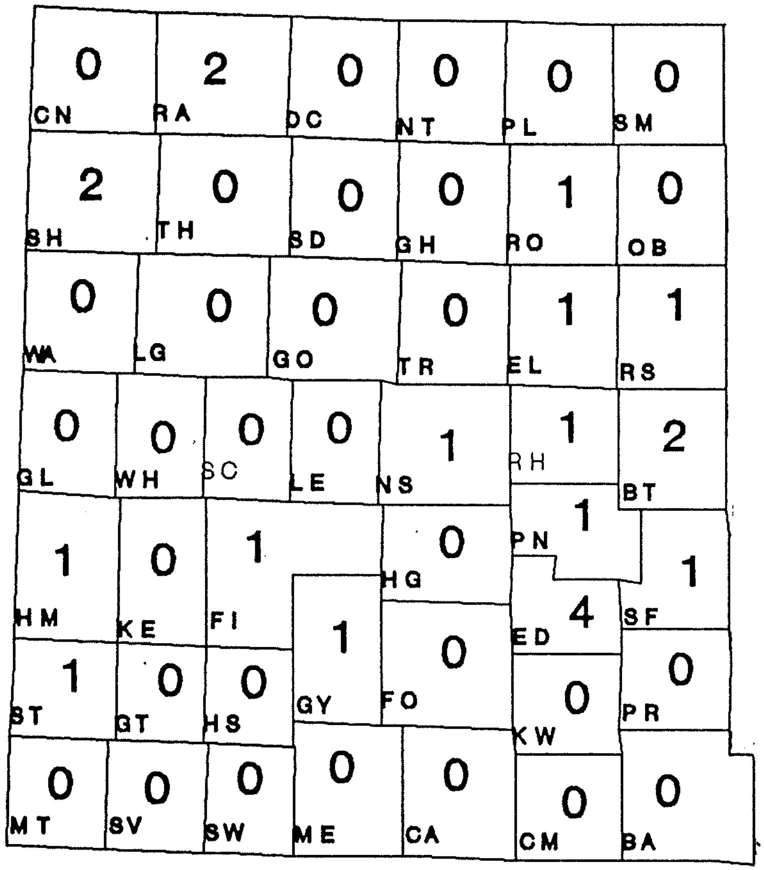
* KCC Sites
** Joint KCC/KDHE Sites

Southwest District



2 Hardtner PWS Well #1
3 Wildboy's Land & Cattle Co.**
4 Kiowa PWS Well #2
5 Finney County Landfill
6 Iowa Beef Processors
7 Kalvesta Restaurant
8 Farmland Industries Nitrogen Plant
9 Henry Strecker *
10 MBPXL (Excel)
11 Stake Site
12 Ulysses Gas Processing Co. (Amoco Production Co.)
13 Bill Burch
14 Clawson Ogallala Cleanup
15 Raymond Smith
16 Schrader Stock Well *
17 Colorado Interstate Gas Co.
18 Meade PWS Wells #1 & #2
19 Helium Sales, Inc. (Phillips Petroleum Greenwood)
20 Ransom Co-op
21 Enoch Thompson *
22 L.E. Marlett
23 Stanley Moffet *
24 Maxedon Lease (Pipeline) **
25 Maxedon Lease (Gas Wells) *
26 Bison PWS Wells #1 and #2
27 Dale Ater (Schaffer Contamination)
28 Gene Avey
29 LaCrosse PWS Well
31 Shallow Water Refinery (EZ Serve Refining)
32 Panhandle Eastern Pipeline
33 National Beef Packing, Liberal
34 Kansas Power and Light, Ulysses
35 Kent Rixon *
36 Kent Rixon **
37 Manter PWS #8
38 Raymond Oil *

* KCC Sites
** Joint KCC/KDHE Sites



Leaking Underground Storage Tank Sites

With Contaminated Groundwater

In the Northwest and Southwest Districts

STATISTICAL SUMMARIES OF SELECTED CHEMICAL CONSTITUENTS IN KANSAS GROUND-WATER SUPPLIES, 1976-81

U.S. GEOLOGICAL SURVEY

Open-File Report 83-263

Prepared in cooperation with the

KANSAS DEPARTMENT OF HEALTH

AND ENVIRONMENT

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By Timothy B. Spruill

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Lawrence, Kansas

1983

1-10

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

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Lawrence, Kansas 66044-3897
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Denver, Colorado 80225
[Telephone: (303) 234-5888]

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CONTENTS

ILLUSTRATIONS

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TABLES

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CONVERSION FACTORS

For those readers interested in metric units, the inch-pound units used in this report can be converted to the International System of Units (SI) using the following factors:

Multiply inch-pound unit	By	To obtain SI unit
mile	1.609	kilometer
micromho per centimeter at 25°C (umhos/cm at 25°C	1.000	microsiemens percentimeter at 25°C

1-13

STATISTICAL SUMMARIES OF SELECTED CHEMICAL CONSTITUENTS IN KANSAS GROUND-WATER SUPPLIES, 1976-81

By

Timothy B. Spruill

ABSTRACT

Data on 24 chemical constituents or properties obtained from 766 wells in the Kansas Ground-Water-Quality Monitoring Network between 1976 and 1981 are statistically summarized in this report prepared in cooperation with the Kansas Department of Health and Environment. Minimum, median, and maximum concentrations and percentage of samples above "maximum contaminant levels" established by the U.S. Environmental Protection Agency are presented for all wells in the statewide network.

More detailed areal statistical summaries are presented for nine chemical constituents for which more than 3 percent of the observed concentrations exceeded the "maximum contaminant level" for that constituent. The State was divided into 14 ground-water regions based on water-use and physiographic characteristics. Summaries for these nine constituents include quartile values and percentage of samples with concentrations above the "maximum contaminant level" for each ground-water region. Accompanying maps show median concentrations and percentages of concentrations exceeding the "maximum contaminant levels" established by the U.S. Environmental Protection Agency for each ground-water region.

INTRODUCTION

The potentially detrimental effects of human activities on the quality of surface- and ground-water resources have caused increasing public concern and ultimately have led to enactment of the 1972 Federal Water Pollution Control Act Amendments (Public Law 92-500). The principal objective of this act was to "...restore and maintain the chemical, physical, and biological integrity of the Nation's water." In 1974, the Safe Drinking Water Act (Public Law 93-523) was passed to assure that public drinking-water supplies would meet minimum quality standards and that ground-water supplies would be protected from contamination from underground-waste injection procedures (Spruill and Kenny, 1981, p. 5).

In response to these two pieces of legislation, the Kansas Ground-Water-Quality Monitoring Network was established in 1976, as part of a cooperative program between the U.S. Geological Survey and the Kansas Department of Health and Environment (Spruill and Kenny, 1981, p. 5). Location of wells included in the network between 1976 and 1981 are shown in figure 1. Approximately 2,000 chemical analyses from 766 wells were obtained during this period.

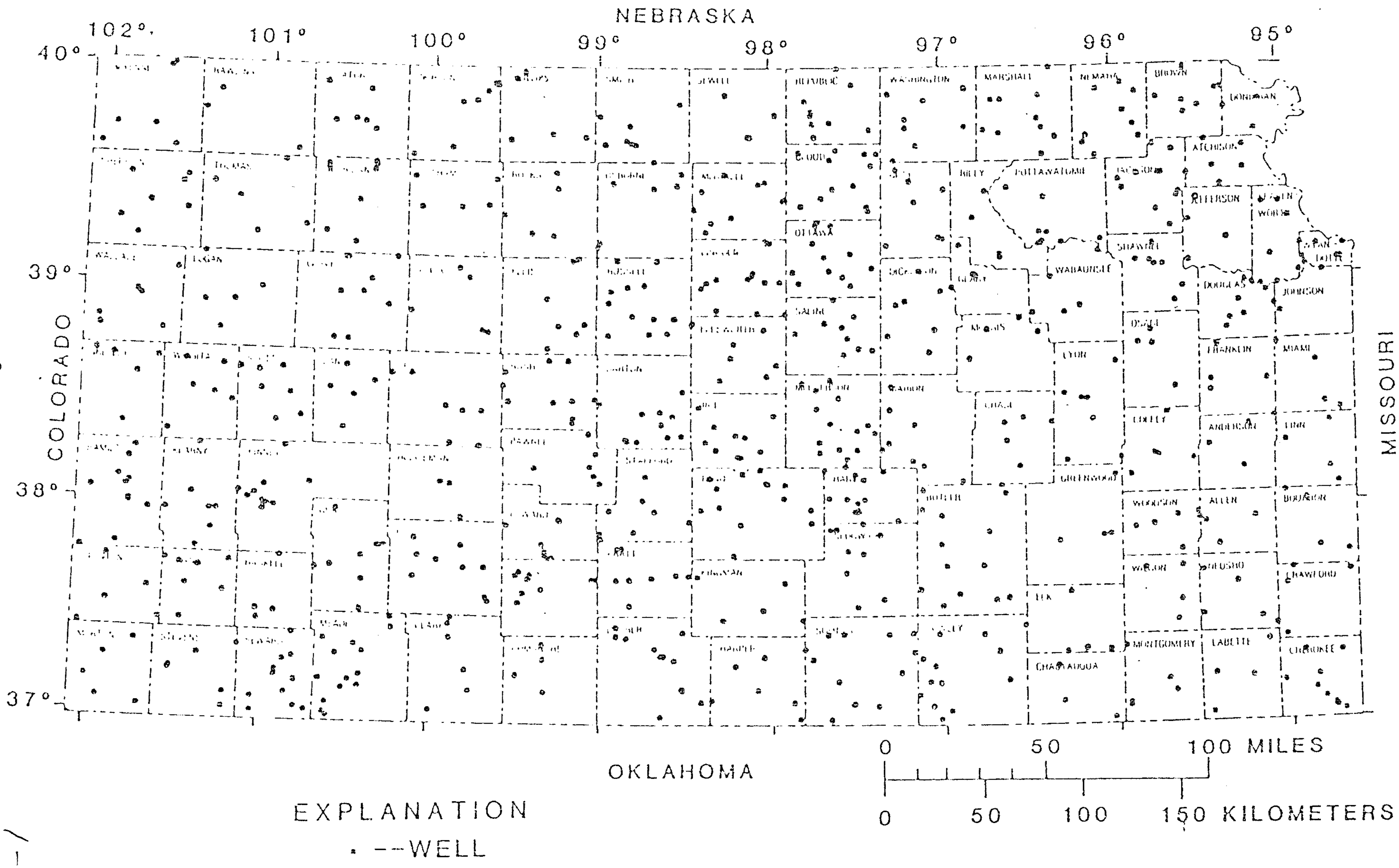

Figure 1.--Location of wells in Kansas Ground-Water-Quality Monitoring Network, 1976-81.

One major objective of the network was to evaluate the obtained data with respect to drinking-water standards imposed by the Safe Drinking Water Act. The purpose of this report is to summarize all data from the network and to provide statistical summaries on selected chemical constituents and properties for which more than 3 percent of the samples obtained exceeded the suggested or mandatory "maximum contaminant levels" established by the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency, 1976; 1977). This information should be useful for the evaluation of regional ground-water supplies throughout Kansas.

METHODS

Selection of Wells and Sample Frequency

Between 1976 and 1981, 766 wells were sampled. Less than 40 wells were sampled during the first year of the network. For 1977-81, between 250 to more than 500 wells were sampled each year. Domestic, public, stock or irrigation wells were selected from well information available for each of 105 Kansas counties in the U.S. Geological Survey's WATSTORE header file. From four to six wells per county were sampled each year. Wells that had previous water-quality information were selected for inclusion in the network.

Wells selected for sampling were to be sampled once annually. Some wells, however, were discontinued during the period for various reasons (for example, the well may have been abandoned or destroyed). Most wells have from two to four analyses available for 1976-81.

Sample Collection and Laboratory Analysis

Samples were collected from wells as described by Wood (1976). Analyses for chemical constituents, trace elements, pesticides, and radiochemicals were made by the Division of Laboratories, Kansas Department of Health and Environment, according to methods described by the American Public Health Association (1975). Chemical constituents and physical properties that were determined are included in table 1. The detection limit for each chemical constituent or physical property is also given. Values below the detection limit are reported as zero.

Table 1.--Schedule of Analysis

[Values below the detection limit for each chemical or physical property or constituent are reported as zero]

Chemical constituent or physical property	Reporting units	Detection limit
Specific conductance	(micromhos)[1]	1
pH	(units)	0.1
Temperature	(degrees Celsius)	.1
Turbidity	(Nephlometric turbidity units)	.05
Hardness as $CaCO_3$	(mg/L)[2]	1
Noncarbonate hardness as $CaCO_3$	(mg/L)	1
Calcium, dissolved	(mg/L)	.1
Magnesium, dissolved	(mg/L)	.1
Sodium, dissolved	(mg/L)	1
Sodium, percent		
Sodium-adsorption-ratio		
Potassium, dissolved	(mg/L)	.1
Bicarbonate	(mg/L)	1
Carbonate	(mg/L)	1
Alkalinity	(mg/L)	1
Carbon dioxide, dissolved	(mg/L)	1
Sulfate, dissolved	(mg/L)	.1
Chloride, dissolved	(mg/L)	.1
Fluoride, dissolved	(mg/L)	.1
Silica, dissolved	(mg/L)	.1
Solids, residue at 180° C, dissolved	(mg/L)	1
Solids, sum of constituents,		
Nitrogen, nitrate dissolved as nitrogen	(mg/L)	.01
Phosphorus	(mg/L)	.01
Arsenic, dissolved	(µg/L)[3]	10
Barium, dissolved	(µg/L)	100
Cadmium, dissolved	(µg/L)	1
Chromium, dissolved	(µg/L)	10
Copper, dissolved	(µg/L)	10
Iron, dissolved	(µg/L)	10
Lead, dissolved	(µg/L)	10
Manganese, dissolved	(µg/L)	10
Mercury, dissolved	(µg/L)	1
Selenium, dissolved	(µg/L)	1
Silver, dissolved	(µg/L)	10
Zinc, dissolved	(µg/L)	10
Carbon, organic total	(mg/L)	.1
Endrin, total	(µg/L)	.1
Lindane, total	(µg/L)	.03

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Table 1.--Schedule of Analysis--Continued

Chemical constituent or physical property	Reporting units	Detection limit
Methoxycholor, total	(μg/L)	.2
/dissolved	(mg/L)	1
PCB, total	(μg/L)	.5
Toxaphene, total	(μg/L)	2
Dacthal, total	(μg/L)	.05
2, 4-D, total	(μg/L)	.4
Silvex, total	(μg/L)	.2
2, 4, 5-T, total	(μg/L)	.2
Gross alpha, suspended total	(pCi/L)[4] as uranium, natural	.1
Radium-226, dissolved	(PCi/L)	.1

[1] Micromhos per centimeter at 25°C.
[2] Milligrams per liter.
[3] Micrograms per liter.
[4] Picocuries per liter.

DRINKING-WATER REGULATIONS AND QUALITY OF KANSAS GROUND-WATER SUPPLIES

The Safe Drinking Water Act (Pl-92-523) was passed with the intent to provide safe drinking-water supplies to the public. As a result of this legislation, primary and secondary drinking-water regulations were promulgated in 1976 and 1977 and are based on criteria established by the U.S. Environmental Protection Agency. Primary regulations pertain to chemical constituents determined to affect the health of consumers and apply to finished (or treated) water supplies. All public-water supplies must be in compliance with these standards. Secondary regulations pertain to chemical constituents that affect the desirability or aesthetic properties of the water for consumptive use. Although secondary regulations are not enforceable, concentrations above "maximum contaminant levels" specified by the U.S. Environmental Protection Agency may render the water highly undesirable or totally unusable without treatment.

Statewide statistical summaries for 24 selected chemical constituents and properties for which primary or secondary regulations have been established are shown in table 2. The first and second columns show the constituent and unit of measurement. The third column shows the "maximum contaminant level" for the constituent or property, which is established by the U.S. Environmental Protection Agency. The fourth through seventh columns give the number of wells sampled and the minimum, median, and maximum concentrations. The eighth column gives the percentage of wells that produced water which exceeded the established "maximum contaminant level."

Table 2.--Statistical summaries of selected chemical constituents and properties of water from wells in the Kansas Ground-Water Quality-Monitoring Network, 1976-81, and "maximum contaminant levels"

[Values are given in milligrams per liter (mg/L), micrograms per liter (µg/L), and picocuries per liter (pCi/L)]

Chemical constituent or property (1)	Unit of measurement (2)	Maximum contaminant level ("MCL") (3)	Number of wells sampled (4)	Minimum concentration 1/ (5)	Median concentration (6)	Maximum concentration (7)	Percent of samples exceeding "MCL" (8)
Arsenic[2]	µg/L	50	623	0	1	50	<1
Barium[2]	µg/L	1,000	623	0	100	2,100	<1
Cadmium[2]	µg/L	10	581	0	0	100	<1
Chromium[2]	µg/L	50	631	0	0	30	0
Lead[2]	µg/L	50	586	0	0	200	<2
Mercury[2]	µg/L	2	569	0	.1	6	1
Nitrate-nitrogen[2]	mg/L	10	758	0	3.5	120	14
Selenium[2]	µg/L	10	641	0	2	134	13
Fluoride[2,3]	mg/L	1.4-2.4	761	.1	.4	6.8	3-10
Endrin[2]	µg/L	.2	165	0	0	0	0
Lindane[2]	µg/L	4	165	0	0	0	0
Methoxychlor[2]	µg/L	100	165	0	0	0	0
Toxaphene[2]	µg/L	5	165	0	0	0	0
2,4-D[2]	µg/L	100	161	0	0	0	0
Silvex[2]	µg/L	10	161	0	0	.2	<1
Gross-alpha[2]	pCi/L	15	153	0	4.9	44	10
Chloride	mg/L	250	760	2	32.5	3,800	8
Copper	µg/L	1,000	631	0	0	1,700	<1
Iron	µg/L	350	613	0	20	15,000	11
Manganese	µg/L	50	612	0	10	3,300	20
pH[4]	units	5.5<pH<8.5	763	5.6	7.3	9.0	1
Sulfate	mg/L	250	766	4	73	2,800	16
Zinc	µg/L	5,000	631	0	20	9,300	<1
Dissolved solids	mg/L	500	612	83	442	2,850	40

1 Zero values indicate concentrations less than the detection limit for each chemical constituent or physical property.

2 Constituents having primary drinking-water regulations.

3 The "maximum contaminant level" for fluoride ranges from 1.4 to 2.4 mg/L, depending upon the mean annual temperature of the region. In this analysis, 10 percent exceeded 1.4 mg/L, and 3 percent exceeded 2.4 mg/L.

4 Drinking water should not be less than 5.5 and greater than 8.5 pH units. No measurements were obtained that were less than the lower limit of 5.5.

GROUND-WATER REGIONS OF KANSAS

To allow water managers to assess possible regional water-quality problems within the State, Kansas was divided into 14 ground-water regions, which are relatively homogeneous with respect to topographical, geological, land-use, and water-use features and are similar to physiographic divisions of the State presented in Schoewe (1949). These ground-water regions are shown in figure 2.

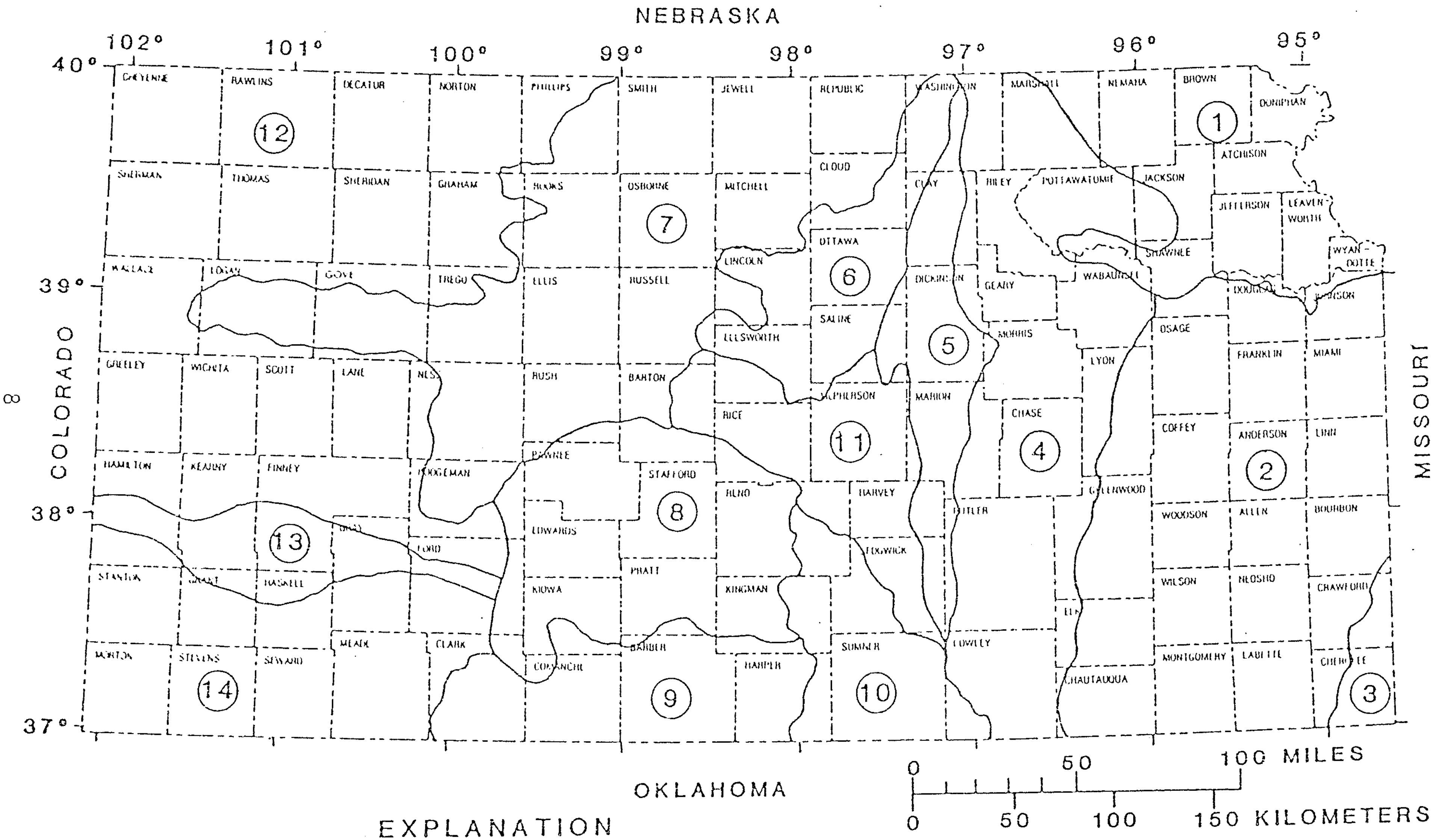
The following narratives describe general characteristics of regional water supplies, geology, and principal aquifers within each region. Estimates of the relative importance of ground- and surface-water supply sources were based in part on information in "The Kansas State Water Plan Studies--Long-range water supply problems, phase I," (U.S. Bureau of Reclamation, 1974).

1.) Approximately one-half of all water supplied for region 1 is derived from ground-water reservoirs. The principal aquifers used for public supplies in the region are unconsolidated glacio-fluvial sand and gravel deposits of Pleistocene age. Unconsolidated alluvial deposits, particularly in large stream valleys, also are major sources for irrigation, public, and domestic stock supplies. Rural domestic and stock supplies are obtained from Permian-age limestones in the western part of region 1, and are derived from Pennsylvanian-age limestones, shales, and sandstones in the eastern part. A few public supplies are also derived from Pennsylvanian sandstones in the eastern part.

2.) Less than 20 percent of water supplied for region 2 is derived from ground-water reservoirs. Most of the ground-water is used primarily for domestic and stock supplies. The principal aquifers are composed of limestones, shales, and sandstones of Pennsylvanian age with the best aquifers composed of sandstones. Most public supplies are derived from surface-water sources. Most wells in this area are developed in the upper weathered portion of Pennsylvanian-age rocks, and well depths range from less than 20 feet to more than 250 feet, with most probably less than 80 feet in depth.

3.) Ground-water reservoirs provide almost all water for public, domestic, and stock uses in region 3. Most public and domestic supplies are derived from Cambrian- and Ordovician-age dolomites. Well depths are usually more than 500 feet in these deep aquifers. Small domestic and stock supplies are derived from rocks of Mississippian age in the southeastern part where well depths range from 150 to 400 feet; shallow wells of less than 30 feet in depth also supply water for small domestic and stock supplies from Pennsylvanian-age sandstones and shales in the western part.

4.) Ground-water reservoirs supply more than a one-third of water supplies in region 4 . Limestones of Permian age are used for domestic, stock, and public supplies throughout much of the region, with the principal uses being for domestic and stock supplies. Wells generally range from 50-200 feet in depth. Unconsolidated alluvial deposits in the larger river valleys supply water for irrigation, public, domestic, and stock supplies. Wells in these alluvial deposits generally range between 20 and 100 feet in depth.



EXPLANATION

① -- GROUND-WATER REGION AND NUMBER

Figure 2.--Ground-water regions of Kansas.

5.) Permian-age shales and limestones containing beds of gypsum and anhydrite provide domestic, stock, and, in the central and southern part, some public supplies. Wells are typically less than 100 feet in depth. Generally, however, well yields are poor, and surface water provides most public supplies for region 5. Irrigation, public, domestic, and stock supplies are derived from alluvial deposits in the Kansas River valley in the north-central part of the region.

6.) Ground water is the source of more than one-half of all water used in region 6. Cretaceous sandstones provide public, domestic, and stock supplies throughout the region, with well depths ranging from 20 to over 200 feet in depth. Alluvial deposits in major river valleys are principal water-supply sources for these uses, as well as for irrigation supplies.

7.) Ground water is the major water-supply source in region 7 for public, domestic, and stock uses. Although surface water has been used in the past to supply water for irrigation, ground water is likely to be the major supply for this use in the future. The major source of ground-water supplies are unconsolidated alluvial deposits in the river valleys. Small domestic and stock supplies are also derived from Cretaceous-age shales, limestones and sandstones, with sandstones providing public supplies as well in the southern part.

8.) Ground water is the major water-supply source in region 8. Thick deposits of unconsolidated sand and gravels of Pleistocene and Miocene age comprise the major aquifer in this region, although shallow (less than 80-feet thick) alluvial deposits in the Arkansas, North and South Fork of the Ninnescah, Chikaskia, and the Pawnee River valleys are significant aquifers. Cretaceous-age rocks subcrop in the western part of region 8 and are also used for water supplies to a limited extent. Permian-age rocks subcrop in the eastern part but are not significant sources of usable water.

9.) More than 90 percent of water supplied for public, irrigation, domestic, and stock uses are obtained from ground-water reservoirs in region 9. Principal sources of ground water for most uses are Pleistocene-age alluvial sands and gravels in stream valleys. Domestic and stock supplies are also derived from Permian shales and sandstones in the region.

10.) Ground water is the primary source of water supply in region 10. Ground-water supplies for public, irrigation, domestic, and stock uses are derived from unconsolidated deposits of Pleistocene age, terrace and alluvial deposits. Most wells in these aquifers are less than 50 feet in depth. Permian-age limestones and shales provide small supplies for domestic, stock, and, in a few cases, public uses.

11.) Ground water is the major water-supply source in region 11. Unconsolidated outwash deposits of Pleistocene age, which range in thickness from less than 40 feet at the edges to over 300 feet in ancient buried channels, are the principal water-supply source. Alluvial deposits of the Arkansas and Little Arkansas Rivers, which are generally less than 100 feet in thickness, also provide a major source of ground water for the region. Permian-age rocks subcrop throughout most of this region.

12.) Ground-water reservoirs provide, almost exclusively, water for irrigation, public, domestic, and stock supplies in region 12. Unconsolidated Tertiary deposits of up to 450 feet in thickness are the source of most water in the region, with most wells being more than 150 feet deep. Pleistocene-age deposits also provide water for most uses, with well depths of less than 100 feet. A few domestic and stock supplies are derived from Cretaceous-age sandstones in the southwestern corner of this region. Cretaceous-age rocks subcrop throughout this area.

13.) Ground water from unconsolidated alluvium in the western part of region 13 and from alluvium and deep Miocene deposits in the eastern part are the main sources for public, domestic, irrigation, and stock uses. Cretaceous-age shales and sandstones provide some domestic and stock supplies in the western part. Cretaceous-age bedrock subcrops through most of the area.

14.) Ground water from unnconsolidated deposits of Miocene age provide most supplies for region 14, with unconsolidated Pleistocene-age alluvium providing some irrigation, domestic, and stock supplies. Some domestic and stock supplies are also obtained from Cretaceous-age sandstones in the western part. Permian-age rocks subcrop throughout most of this region.

STATISTICAL SUMMARIES OF SELECTED CHEMICAL CONSTITUENTS

The following statistical summaries are presented for dissolved-solids, chloride, fluoride, iron, nitrate-nitrogen, manganese, selenium, sulfate, and total gross-alpha concentrations in Kansas ground-water supplies. Concentrations for each of these constituents exceeded the "maximum contaminant levels" for more than 3 percent of the wells sampled (see table 1). Data for each chemical constituent were first summarized by computing median values for each well. One to six analyses were included for each well. Data for each chemical constituent then were summarized by area (ground-water regions 1-14 in figure 2).

Tables 3-11 show values for the first, second, third, and fourth quartiles and the percentage of wells sampled that exceeded the "maximum contaminant levels" for each ground-water region. The first quartile value represents the concentration where 25 percent of the observed concentrations were less than this value. The second quartile value (or median) is the value for which 50 percent of the concentrations were below the specified value. The third quartile value is the concentration for which 75 percent of the observed concentrations were less than this value. The fourth quartile value (or maximum) is the maximum observed concentration. Figures 3-11 show the approximate median concentrations and percentages exceeding the "maximum contaminant level" for each of the 14 ground-water regions.

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1-24

Table 3.--Dissolved-solids concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (milligrams per liter)				Percent above "MCL"[1]/
		1st	2nd (median)	3rd	4th (maximum)	
1	61	344	439	522	943	31
2	67	297	432	673	1,170	39
3	7	294	562	593	997	71
4	53	408	480	640	842	33
5	12	254	575	701	919	58
6	55	349	454	682	975	42
7	74	506	646	784	1,090	77
8	52	258	294	368	711	6
9	14	363	470	640	780	50
10	21	306	411	643	832	38
11	40	409	522	648	951	57
12	88	325	371	500	975	25
13	22	304	370	651	2,850	26
14	45	329	381	504	907	24

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

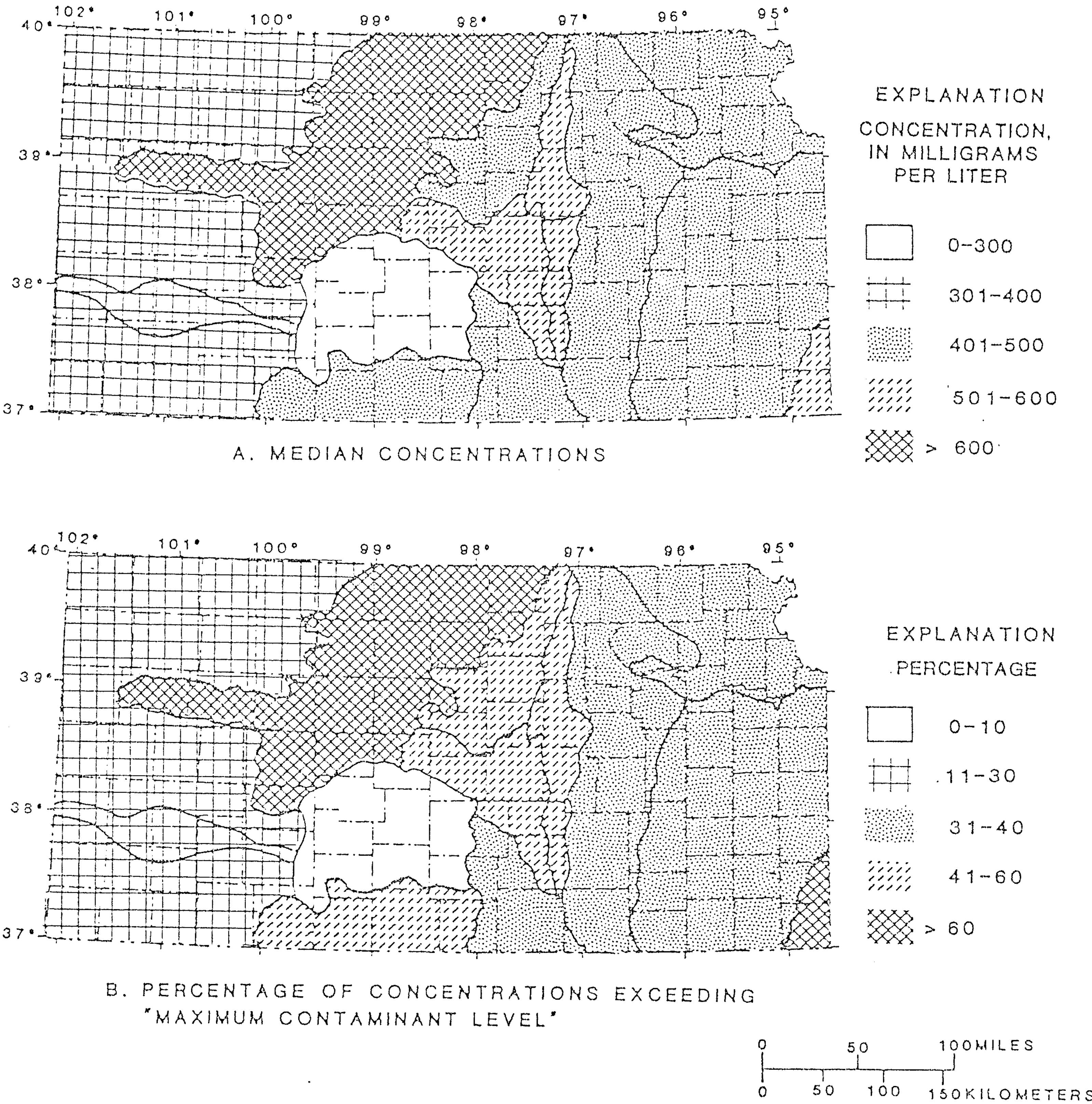


Figure 3.--Dissolved-solids concentrations in Kansas ground-water supplies.

Table 4.--Dissolved chloride concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (milligrams per liter) 1st	2nd (median)	3rd	4th (maximum)	Percent above "MCL"[1]
1	71	9.5	19	59	910	6
2	83	16	33	82	2,215	10
3	9	36	170	392	640	40
4	60	.4	.7	1	15	0
5	18	19	29	73	360	6
6	62	17	33	92	430	6
7	111	39	65	150	3,800	12
8	62	12	20	44	2,000	3
9	25	29	88	207	3,225	16
10	24	16	41	238	1,100	25
11	50	26	80	140	690	16
12	96	14	23	44	140	0
13	29	11	24	106	370	7
14	59	15	19	32	350	3

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

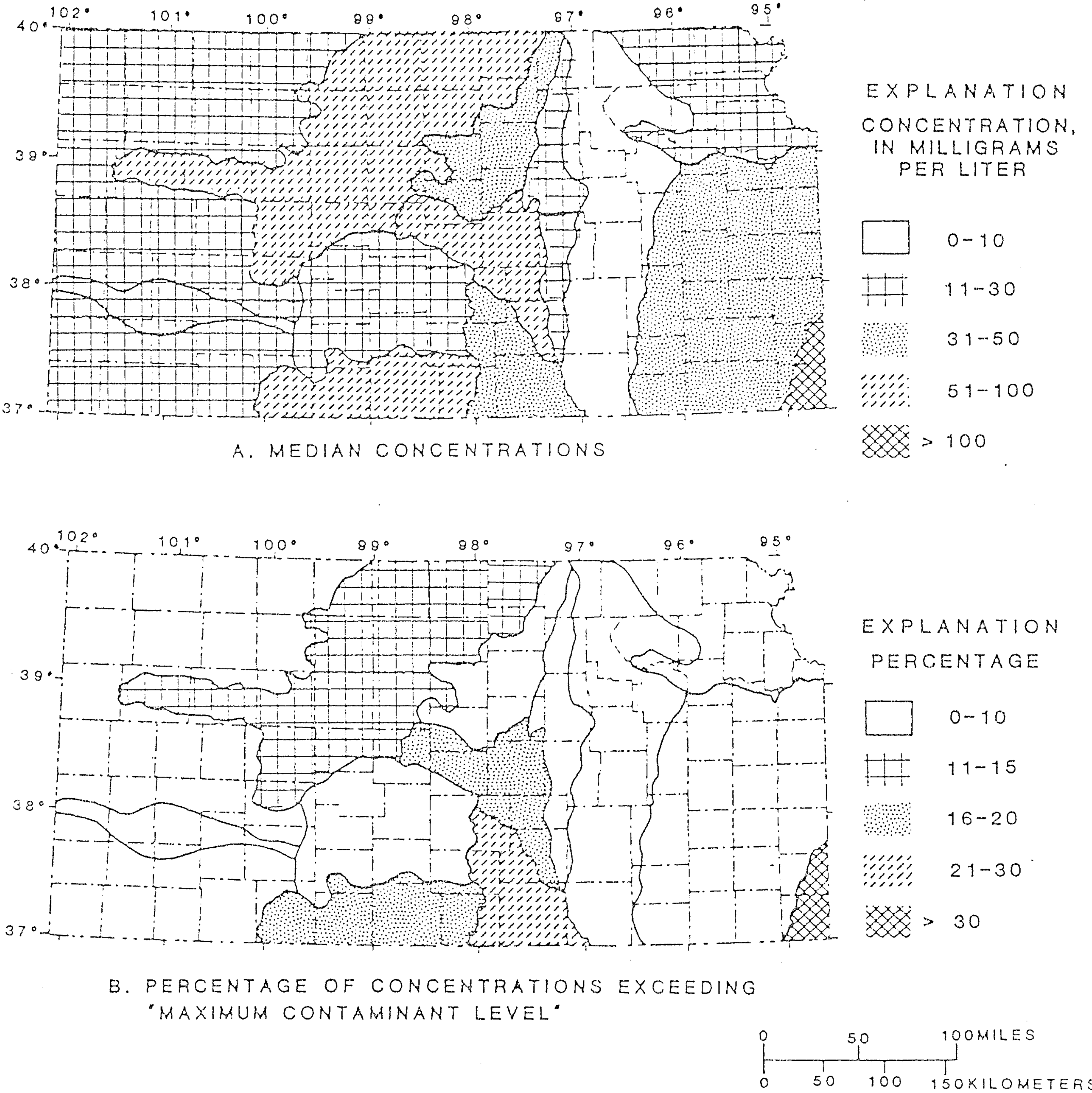


Figure 4.--Dissolved chloride concentrations in Kansas ground-water supplies.

Table 5.--Dissolved fluoride concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (milligrams per liter) 1st	2nd (median)	3rd	4th (maximum)	Percent above "MCL"1/
1	71	0.2	0.3	0.40	1.1	0
2	82	.2	.3	.50	6.5	8
3	10	.3	.8	1.5	2.2	30
4	60	.2	.3	.4	1.4	<2
5	18	.3	.4	.7	1.2	0
6	62	.2	.3	.4	1.5	<2
7	111	.3	.4	.7	6.4	13
8	62	.2	.3	.4	1	0
9	25	.4	.5	.7	1.2	0
10	24	.1	.2	.3	6.8	4
11	53	.2	.3	.5	1	0
12	95	.6	1.1	1.7	3.5	35
13	29	.5	.9	1.2	1.8	13
14	59	.5	.8	1.1	3.6	14

1/ "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977). 2.4 mg/L is considered the "MCL" for all regions in this report, although the actual "MCL" depends on the regional mean annual temperature.

1-29

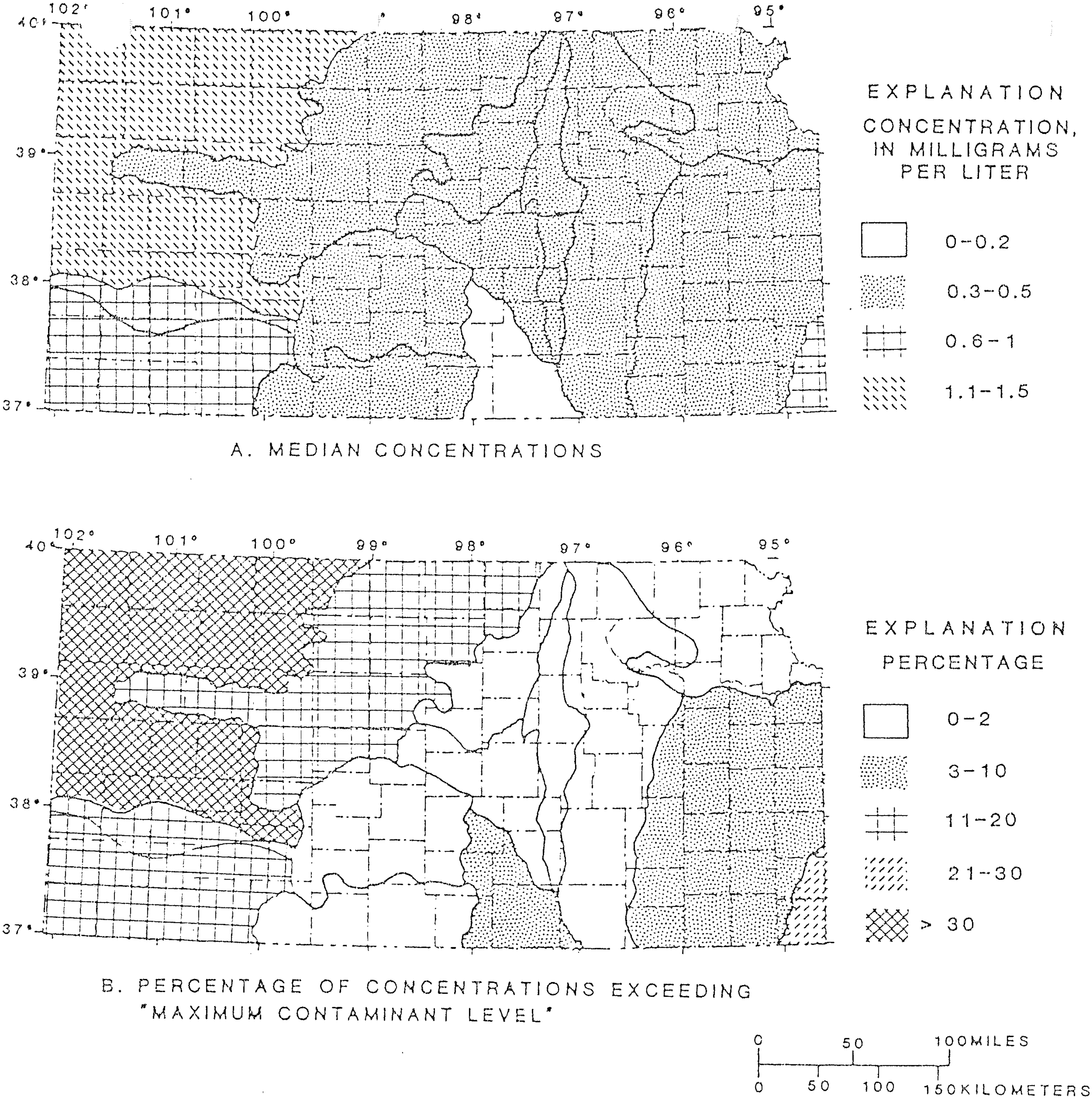


Figure 5.--Dissolved fluoride concentrations in Kansas ground-water supplies.

1-30

Table 6.--Dissolved iron concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (micrograms per liter) 1st	2nd (median)	3rd	4th (maximum)	Percent above "MCL"[1/]
1	62	10	30	510	15,000	26
2	73	10	20	50	5,900	5
3	9	35	80	1,200	1,700	44
4	54	10	15	40	3,600	11
5	17	10	10	30	1,300	18
6	40	20	40	468	9,600	25
7	85	20	30	160	8,400	19
8	47	10	10	20	500	4
9	18	10	12	65	550	6
10	14	10	20	30	40	0
11	40	10	20	48	3,000	10
12	81	10	10	20	2,900	4
13	17	10	10	20	180	0
14	54	10	10	11	120	0

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

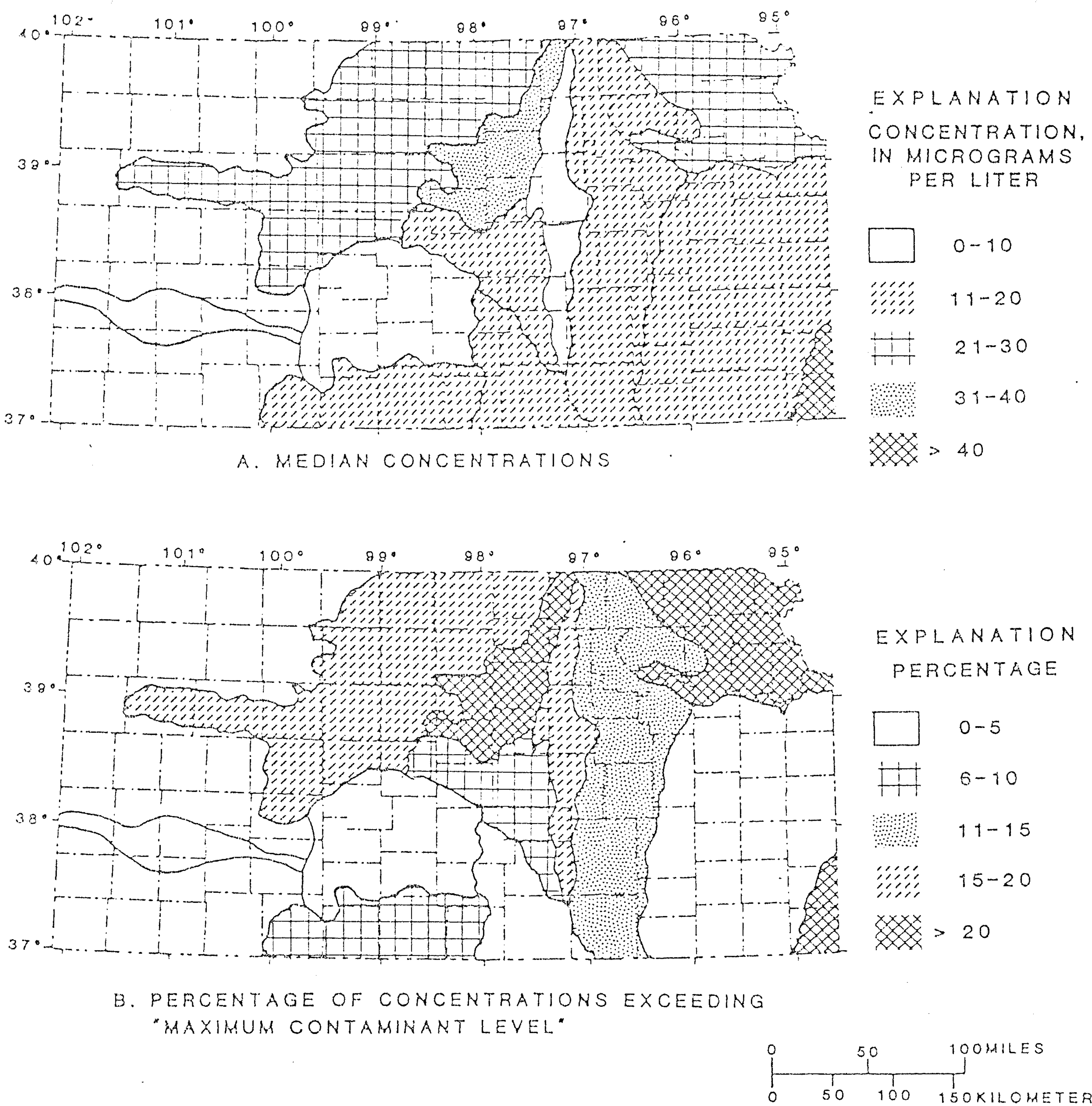


Figure 6.--Dissolved iron concentrations in Kansas ground-water supplies.

Table 7.--Dissolved nitrate-nitrogen as (N) concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (milligrams per liter) 1st	2nd (median)	3rd	4th (maximum)	Percent above "MCL"[1]
1	71	0.1	1.5	7.0	89	13
2	82	.7	4.0	13	120	30
3	10	0	0	0	.6	0
4	60	1.2	3.9	7.8	15	11
5	18	.2	2.7	10	28	22
6	62	.3	2.8	6.1	87	14
7	112	.4	2.8	6.6	56	14
8	62	3.7	5.6	8.7	29	11
9	25	.6	2.7	8.0	41	20
10	24	.9	3.2	7.4	13	8
11	53	.6	3.4	5.8	26	10
12	95	3.1	4.5	6.0	32	6
13	28	.3	2.7	6.7	21	11
14	48	.1	3.2	3.9	13	2

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

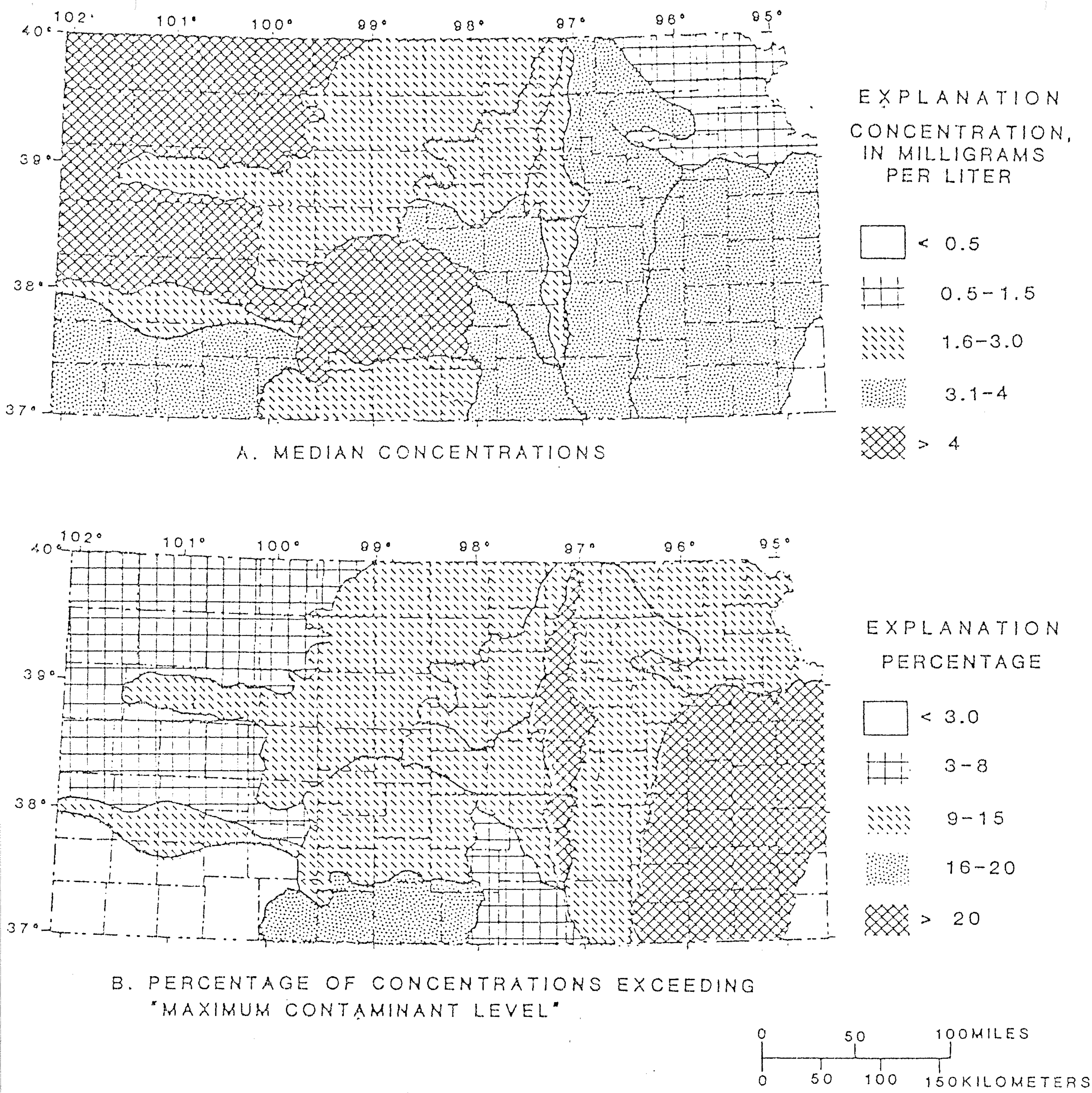
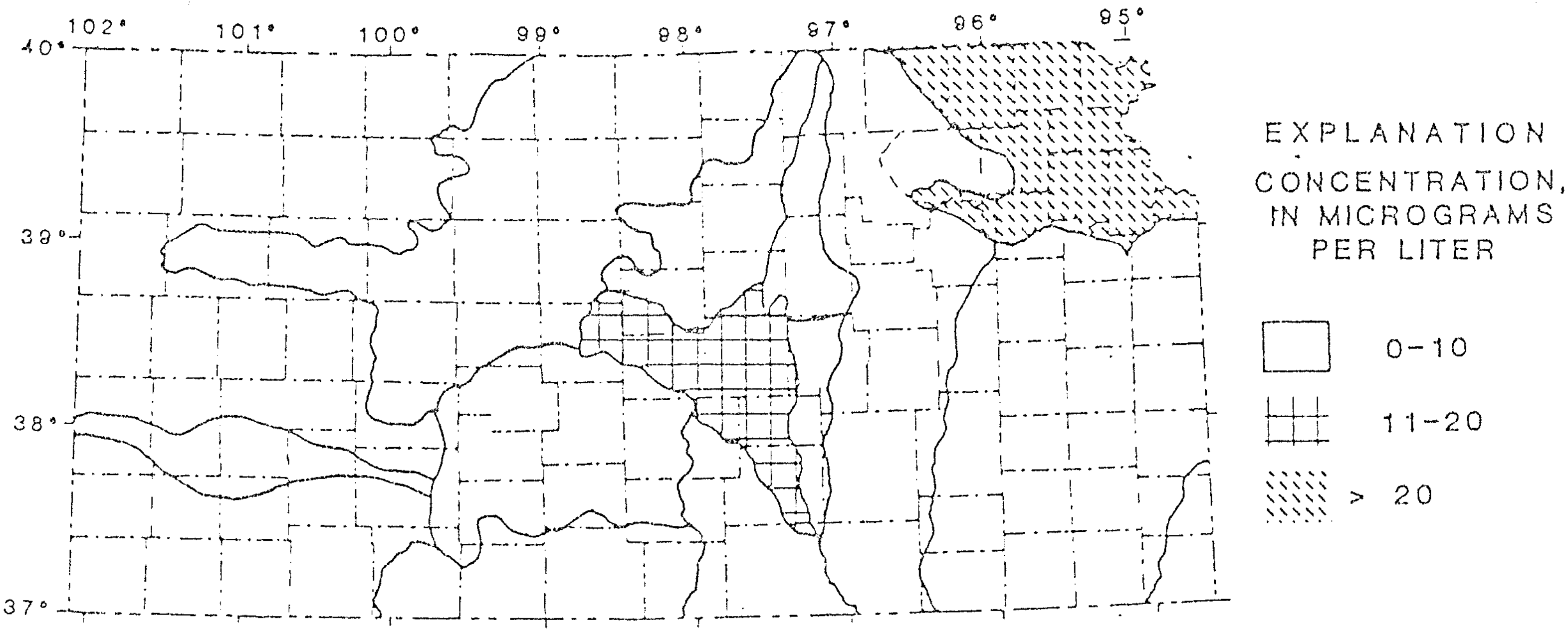


Figure 7.--Dissolved nitrate-nitrogen concentrations in Kansas ground-water supplies.

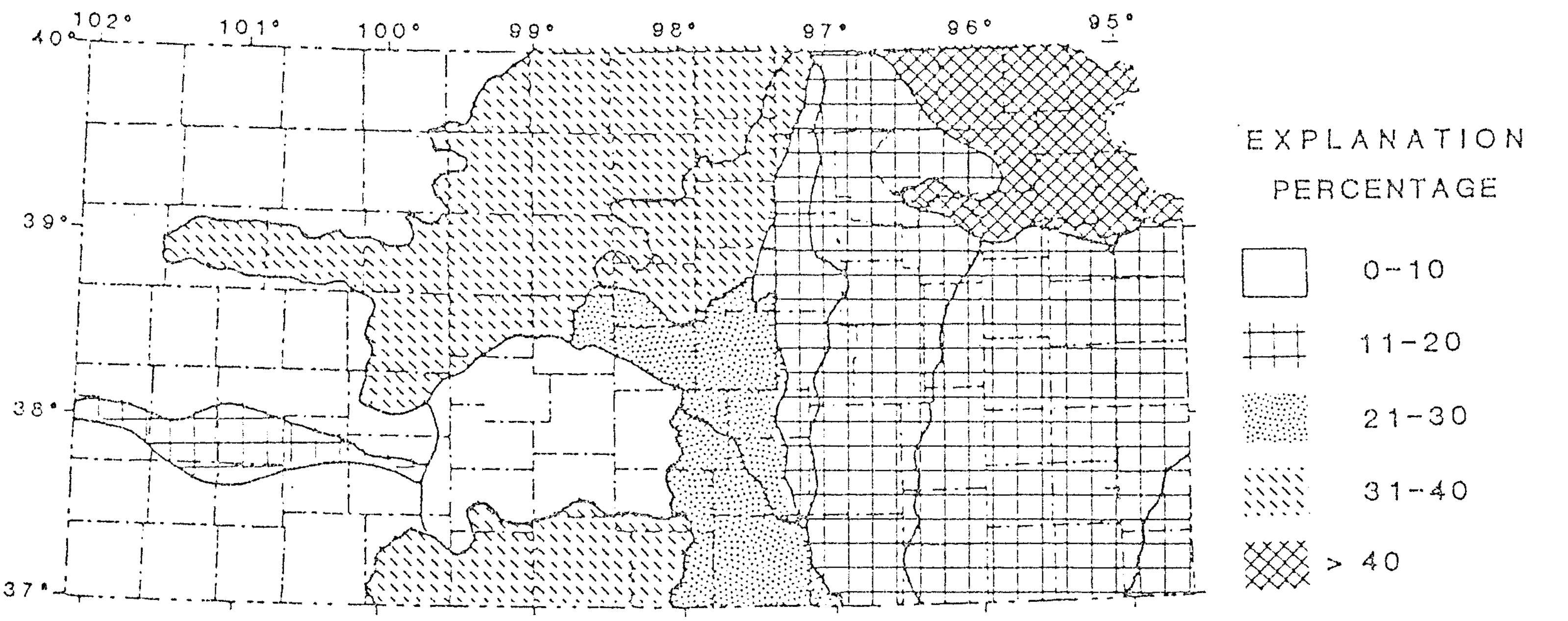
Table 8.--Dissolved manganese concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (micrograms per liter) 1st	2nd (median)	3rd	4th (maximum)	Percent above "MCL"[1]
1	62	10	30	265	1,700	43
2	73	10	10	20	2,200	18
3	9	10	10	25	60	11
4	54	10	10	20	3,300	18
5	17	10	10	55	75	18
6	40	10	10	110	1,300	35
7	85	10	10	140	960	32
8	47	10	10	10	120	4
9	18	10	10	158	460	33
10	14	10	10	30	780	21
11	40	10	20	48	3,000	25
12	80	10	10	10	980	9
13	17	10	10	20	180	12
14	54	4.5	10	10	10	0

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).



A. MEDIAN CONCENTRATIONS



B. PERCENTAGE OF CONCENTRATIONS EXCEEDING "MAXIMUM CONTAMINANT LEVEL"

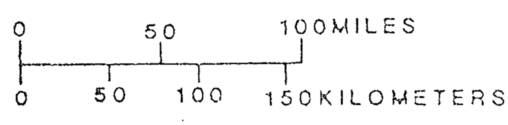


Figure 8.--Dissolved manganese concentrations in Kansas ground-water supplies.

1-36

Table 9.--Dissolved selenium concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (micrograms per liter)				Percent above "MCL"[1]
		1st	2nd (median)	3rd	4th (maximum)	
1	61	0	1	1.5	46	4
2	74	0	1	2	134	4
3	9	0	1	1.5	3	0
4	58	1	1.5	4	16	2
5	17	2	3	19	100	30
6	49	1	2	4.5	50	14
7	91	1	5	13	84	32
8	62	1	1	2	11	4
9	19	1	2	5	25	5
10	22	1	1.5	4	17	9
11	44	1	1.5	3	22	13
12	101	2	4.5	7	39	20
13	17	3.5	10	21	29	52
14	54	3	4	7	31	16

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

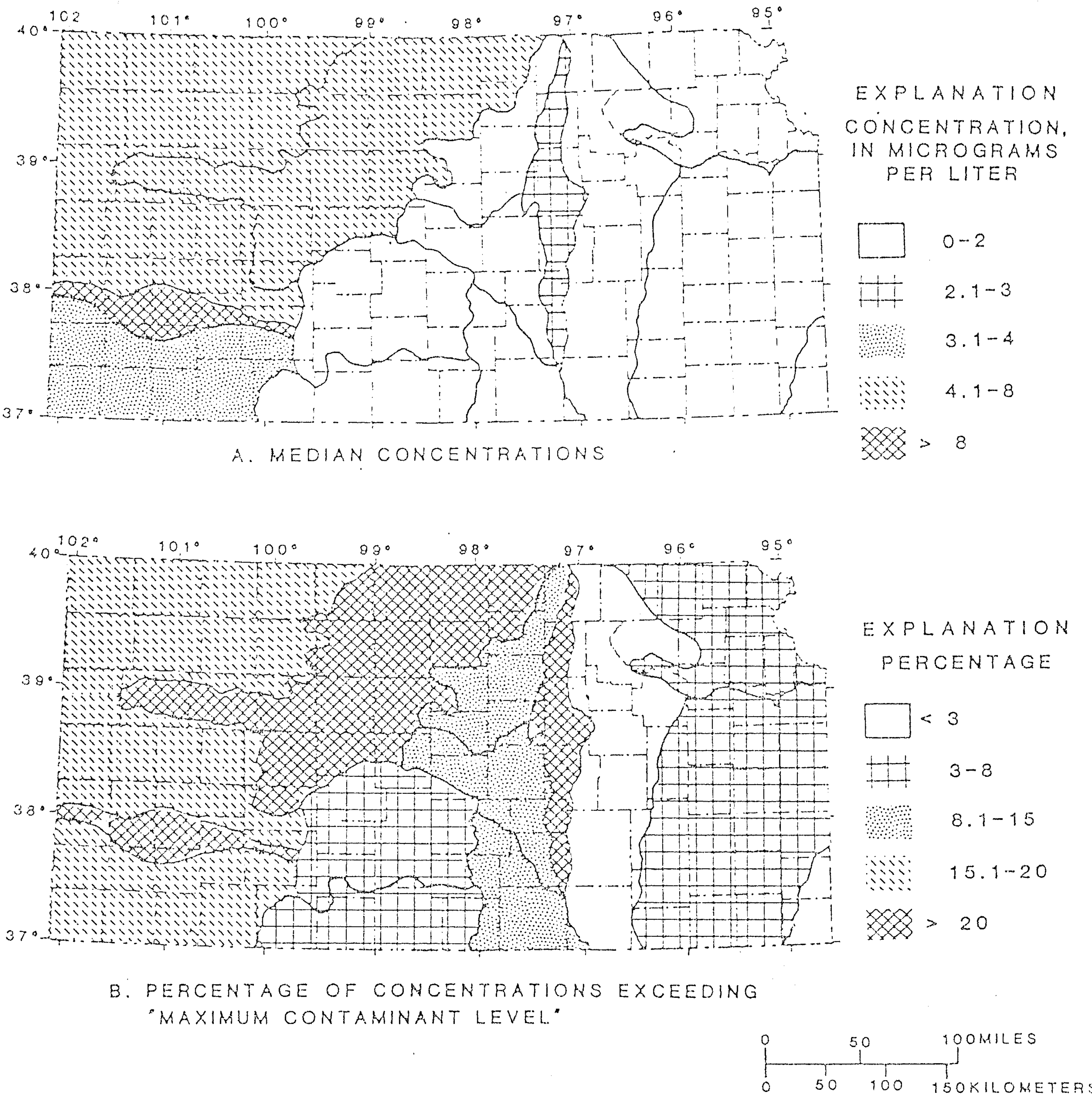


Figure 9.--Dissolved selenium concentrations in Kansas ground-water supplies.

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Table 10.--Dissolved sulfate concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (milligrams per liter) 1st	2nd	3rd	4th	Percent above "MCL"1/
1	71	21	44	76	1,200	7
2	83	36	74	165	1,800	20
3	10	36	92	155	610	10
4	60	30	62	180	1,500	15
5	18	51	275	930	1,950	56
6	62	39	79	210	1,700	14
7	112	92	160	338	1,700	33
8	62	13	20	37	630	3
9	25	80	260	806	2,000	52
10	24	25	70	116	1,000	8
11	53	29	57	95	500	4
12	96	33	52	108	630	2
13	29	76	160	1,105	2,800	40
14	59	53	90	140	325	5

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

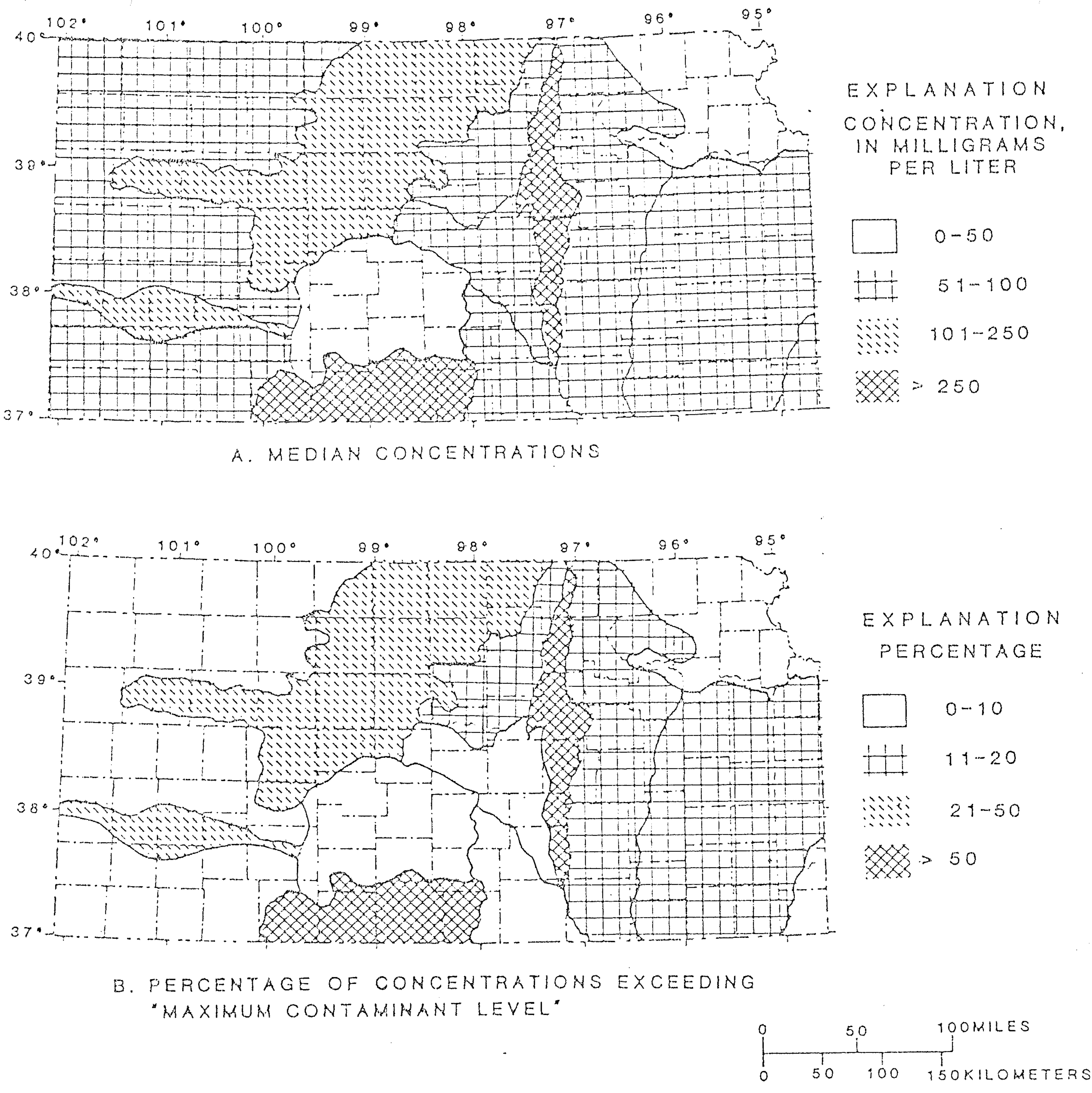

Figure 10.--Dissolved sulfate concentrations in Kansas ground-water supplies.

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Table 11.--Total gross-alpha concentrations in Kansas ground-water supplies

Ground-water region	Number of samples	Quartile values (picocuries per liter) 1st	2nd (median)	3rd	4th (maximum)	Percent above "MCL"[1]/
1	17	2	3	4.5	11	0
2	16	2	2	3	44	6
3	8	7.2	9.5	11.2	27	12
4	7	4	6	8	12	0
5	no data	--	--	--	--	--
6	9	2.5	3	9	15	10
7	18	4	8	10.5	38	16
8	5	1.5	4	7.5	8	0
9	no data	--	--	--	--	--
10	5	.5	3	4	5	0
11	12	2	3.5	8.8	11	0
12	9	6.5	9	10	18	11
13	3	--	--	--	--	--
14	no data	--	--	--	--	--

1 "MCL" is the "maximum contaminant level" established by the U.S. Environmental Protection Agency (1976; 1977).

1-41

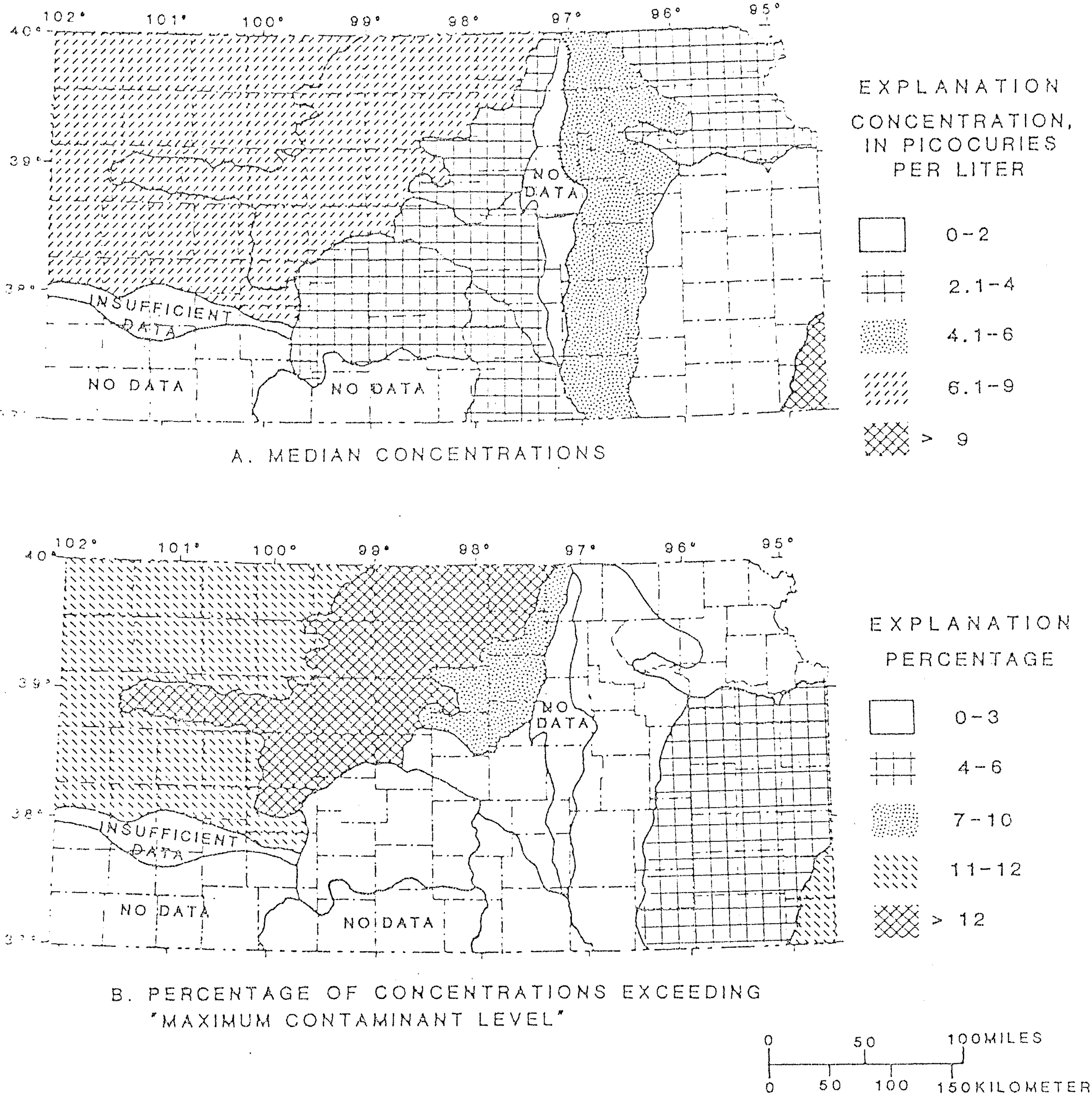

Figure 11.--Total gross-alpha concentrations in Kansas ground-water supplies.

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NORTHWEST KANSAS GROUNDWATER MANAGEMENT DISTRICT 4

Presentation before House of Representatives

Energy and Natural Committee

March 14, 1990

AUTHORITIES AND PROGRAMS OF GMD 4

GMD POWERS AND AUTHORITIES

The Kansas GMDs were well endowed with authority when the legislature developed the Kansas Groundwater Management Districts Act. KSA 82a-1028 sets forth the following powers and authorities:

a) To sue and be sued;
b) Maintain, equip and staff an office;
c) Hold and sell property and water rights;
d) Acquire land up to 1000 acres by gift or exchange;
e) Construct and operate works for drainage, recharge, storage, distribution or importation of water;
f) Levy water user charges and land assessments, issue bonds and incur indebtedness;
g) Contract with persons, firms, associations or agencies of state or federal government;
h) Extend or reduce district boundaries;
i) Conduct research and demonstration projects;
j) Require installation and reading of meters or gauges;
k) Provide assistance in the management of drainage, storage, recharge, surface water and other problems;
l) Adopt, amend and enforce by suitable action policies relating to the conservation and management of groundwater;
m) Recommend to the Chief Engineer rules and regulations necessary to implement and enforce board policies;
n) Enter upon private property for inspection purposes to determine conformance with policies;
o) Seek and accept grants or other financial assistance from federal, public or private sources; and
p) Recommend to the Chief Engineer the initiation of proceedings to establish an intensive groundwater use control area.

H Energy and NR
3-14-90

Attachment 2

REGULATIONS AND POLICIES

GMD 4 has used these powers and authorities to develop its management programs, regulations and policies as follows:

a. Allowable Withdrawals: (Quantity) Controls the rate of new Ogallala appropriations by disallowing new water rights to be approved when the addition of the new well will cause the water table to decline at a rate in excess of 1% of the current saturated thickness. Using averages, this means that only 1700 acrefeet of total water rights will be allowed from within any 2-mile (8,042 acre) area. Again using averages, this equates to the water rights 6 irrigation wells would possess.

b. Well Spacing: (Quantity) Mandates minimum distances new wells can be drilled from existing wells. The policy contains variable spacings based on the amount of water being diverted - ranging between 1400 feet and 2800 feet. Dakota wells are spaced 5000 feet apart. The spacing policy is to prevent direct interference only. The regional decline issue is addressed by the allowable withdrawals policy.

c. Alluvial Corridors: (Quantity) Designates which water ways have mandatory no-development corridors and the distance of the set-back restrictions. Theses corridors range in width from 1500 feet on either side (3000 feet total width) to 5000 feet in width (10,000 feet total width) on either side and are set such that no stream-associated alluvial formation would be omitted.

d. Abandoned Wells: (Quality) Mandates proper handling of abandoned wells within the district, sets technical criteria for remediation and establishes the administrative program. To date over 2100 abandoned wells have been identified and approximately 1500 have been remediated. The final 750 are currently in the process of remediation with all owners having been at least notified. Most current status report is attached. This program has also allowed the district to handle any in-use wells which are improperly constructed.

e. Tailwater Control: (Quantity) Mandates control of irrigation runoff and, if feasible, its re-use. This program is considered to be the most aggressive tailwater program in the state, if not the Midwest. When a violation is identified, a formal District Order is automatically issued requiring water control. If not complied with, a court injunction requiring an irrigation development plan is automatically sought.

f. Well Construction: (Quality) Mandates proper well construction within the district. GMD 4 has adopted state construction specifications and locally enforces well construction standards. Just recently a well contractor was issued a District Order to return and re-complete an insufficient water well. This entire process was completed within 14 days from district inspection to well work completion.

g. Resource Development Plans: (Quantity) Requires irrigation efficiency plans on all new and changed water right applications and all existing water rights with chronic water control problems. This policy when developed in 1986 was a first for the state which mandates a pre-set irrigation water use efficiency (approximately 80-85%) for all applicable water rights. This local program was the model for the state program which became effective January 1, 1989.

h. Water Diversions: (Quantity and Quality) Requires that all groundwater diversions from within the district be made according to all state and local statutes, rules and regulations. This general statement gives the GMD significant added authority when coupled with its enforcement policy.

i. Metering: (Quantity) Since May 1, 1980 the district has required operational and permanent meters on all new wells drilled. To date there exists approximately 350 district-required meters on wells.

j. Allowable Appropriations: (Quantity) This policy sets the maximum quantities of water which are allowed to be appropriated by the major use types. Irrigation water amounts are held to a maximum of 2715 hours of annual pumpage for their diversion rate or 2 acre-feet per acre, whichever is less. With the new water use data being developed by DWR and KWO, particularly regarding municipal use, this policy will show up revised in the district's next management program due to go into effect soon.

k. Changes in Points of Diversion: This district policy limits the maximum distance an existing well can be re-located to 2640 feet, provided well spacing is met at the new location. It also controls the possibility of supplemental (additional) wells under an existing water right.

l. Non-Compliance: This policy provides for the issuance of a District Order mandating compliance when any policy is being violated. It is the heart of our local enforcement mechanism and has worked very efficiently to date. Thus far it has been used to enforce the district's metering, tailwater control, abandoned wells and resource development plan policies.

CURRENT PROGRAMS OF NOTE

a. Water Quality Monitoring: (Quality) Selected wells within pre-determined quality grids are monitored annually for a specific range of constituents expected to be found within the grid. Sixteen grids have been established around representative samples of possible contamination within the district.

b. Public Education: (Quantity and Quality) The district publishes a Newsletter 6 times annually. It has not missed an edition since its inception in December, 1977. Intermittent radio, television and newspaper coverage is also provided on a case-by-case basis. The local office also provides a source of water information which will is as convenient as it may ever get.

c. Data Collection: (Quantity and Quality) Water level, bedrock, water quality, water rights appropriations, and other water-related data are collected and kept at the office in conjunction with many state agencies. All locally collected data is made readily available to any state agency requesting same.

d. Water Rights Administration: (Quantity, some Quality) The district office assists the public with water rights work and processing applications when district development policies can be met.

e. Nitrate Study: (Quality) Study of slightly elevated nitrate levels within a small area of the district, now being cooperatively studied with KGS.

DEVELOPING PROGRAMS

a. Withdrawal Reduction: (Quantity) The district board has decided to develop a new program aimed at delineating all areas of unacceptable water table declines and establishing management programs within these areas for reducing pumpage to the extent necessary to achieve pre-determined goals. As of February 16, 1990 a new water rights development moratorium has been placed over the entire district in order to prevent any water rights approvals which could be subsequently affected by the new program.

A decision tree has been developed regarding the specific steps which will need to be taken in order to achieve program goals, and at this time specific alternatives are being identified and organized for consideration. A copy of the current tree is attached for committee consideration.

A working committee made up of interested district members is now being formed to provide, by recommendation, advice and direction to the board regarding the specific criteria to be used to define "unacceptable water table decline areas".

b. Local Environmental Planning: (Quality) The district has also acted as the main catalyst in the developing Local Environmental Planning Group (LEPG) being formed in 13 northwest Kansas Counties. Acting under a formal Interlocal Agreement, these participating counties have banded together, formed a governing board and made application to KDHE for grant monies available for local environmental planning under the State Water Plan Fund. The LEPG has contracted with GMD 4 to provide office space and direct day-to-day supervision of LEPG staff. As soon as the grant application is approved, the LEPG is ready to advertise for staff and begin developing its regional environmental code.

This co-location and supervisory role for the GMD will ensure that all environmental planning is totally coordinated with existing and developing groundwater management policy, thus putting northwest Kansas significantly closer to being managed and planned for as a total systems district.

There is also an idea now developing which proposes the organization of a parallel Conservation District group to seek non-point source pollution funds for non-point source pollution planning for the identical 13-county area covered by the existing LEPG. The idea is to have non-point source pollution planning moving forward simultaneously with the other environmental plans, yet exactly parallel and coordinated from a single office.

APPENDICES

)4 ABANDONED WELL . .TUS REPORT: March 2, 1990(WELLSTAT)

TOTAL WELLS CONSIDERED BY GMD PROGRAM -- 2154

VOLUNTEER -- 334 15.5%

IN SYSTEM ---------------- 119 35.6%
PLUGGED ---------------- 200 59.9%
CAPPED ---------------- 15 4.5%
RE-BUILT ---------------- 0 0.0%

LOCATED -- 1751 81.3%

IN SYSTEM ---------------------- 598 34.2%

PENDING LTR ---- 20 3.3%
LETTER SENT ---- 446 74.6%
ORDER SENT ---- 132 22.1%

ARCHIVED ---------------------- 1153 65.8%

PLUGGED ---- 852 73.9%
CAPPED ---- 116 10.1%
RE-BUILT ---- 49 4.2%
VACATED ---- 136 11.8%

FOUND RECENTLY PLUGGED ------------------------- 69 3.2%

TOTAL WELLS PLUGGED -- 1121
TOTAL WELLS CAPPED -- 131
TOTAL WELLS RE-BUILT -- 49

GMD 4 ABANDONED WELL /6/88 THRU MOST CURRENT UPDATE

STATUS REPORT DATE	TOTAL WELLS LOCATED	TOTAL WELLS ARCHIVED	WELLS/DAY LOCATED SINCE PREVIOUS UPDATE	WELLS/DAY LOCATED SINCE 9/6/88	WELLS/DAY ARCHIVED SINCE PREVIOUS UPDATE	WELLS/DAY ARCHIVED SINCE 9/6/88
9/6/88	969	289				
10/11/88	1052	354	3.32	3.32	2.6	2.6
11/2/88	1155	402	6.55	4.57	3.05	2.78
11/18/88	1214	424	5.16	4.7	1.93	2.59
1/4/89	1365	525	4.5	4.62	3.01	2.75
2/14/89	1451	553	2.94	4.19	0.96	2.3
3/8/89	1493	623	2.67	4.01	4.45	2.56
4/1/89	1579	669	5.02	4.13	2.68	2.57
5/4/89	1651	746	3.05	3.98	3.27	2.67
6/8/89	1799	812	5.92	4.23	2.64	2.66
6/12/89	1810	839	3.85	4.22	9.45	2.76
7/6/89	1889	856	4.61	4.25	0.99	2.62
8/2/89	2023	870	6.95	4.47	0.73	2.46
9/29/89	2090	922	1.62	4.04	1.26	2.28
(Primary field inspection completed)						
10/31/89	2107	967	0.74	3.79	1.97	2.26
11/30/89	2121	1029	0.65	3.58	2.89	2.3
1/11/90	2154	1087	1.1	3.37	1.93	2.27
2/9/90	2141	1119	-0.63	3.15	1.54	2.23
3/2/90	2154	1153	0.87	3.06	2.27	2.23

DECISIONS TO BE MADE FOR WITHDRAWAL REDUCTION PROGRAM

1. Which water rights to continue under moratorium

   - No change
   - New non-domestic apps only for permanent rights (with notice that all others may be affected by program development - let the applicant beware)
   - Provisions for pre-moratorium water rights planning

2. Who to involve in defining criteria?

   - Board/Staff exclusively
   - Board only with public input via meetings and/or hearings
   - Committee of Board/Public/State to recommend to board
     - President appoint committee
     - Board/staff hand pick diverse committee
     - Solicit volunteers
   - Request state agency (DWR or KWO) to appoint committee

3. Criteria to identify initial areas

   - Water rights per unit area
   - Wells per unit area
   - Calculated potential depletion rate by percentage
   - Calculated potential depletion rate by feet
   - Actual measured depletion rate by percentage
   - Actual measured depletion rate by feet
   - Combination of above

4. Criteria to identify subsequent areas

   - Same criteria as 2. above but more stringent figures
   - Different criteria

5. Goals for areas or each area

   - Water table decline rate to Safe yield
   - Water table decline rate to 1%
   - Water table decline rate to 2%
   - 25% reduction of water use in the area
   - Sliding percentage rate reduction within the area

6. Time frame to reach goals

   - Target date
   - Incremental dates

7. Who to involve in corrective control measure decisions

   - Local public within areas involved
   - Board/Staff decision solely from meetings/hearings
   - State involved with either public or board
   - Combination of above

8. What implementation procedures to use

- Voluntary programs which are easy
- Limit to local administrative policies for maximum flexibility but fewer options
- IGUCA which involves the state but increases options

9. Determine corrective measures and role of metering

- Scheduling
  - Priorities by year
  - 5-year plans
- Efficiency improvement
  - Mandate sprinklers
  - Pumpage limits set
  - Mandate RDPs
- Reduction of Water rights (pumpage)
  - Reverse order of priority
  - Across the board % reduction
  - incremental priority, sliding % reduction
  - Pumpage limits set
  - Buy back program
  - Safe yield cutoff - higher rights reduced
- Selective phase out over time
  - Wells over file # xx,xxx cannot be replaced
  - wells over file # xx,xxx dismissed when xx years old
- Combination(s) of above

OVERRIDING ISSUES

1. We may find that there are areas where the people want to do extra management even if they do not show up in a designated area. When determining the criteria for area identification, should we provide a mechanism for non-identified areas to also adopt withdrawal reduction policies as well, provided the area people are in agreement?

Summary of Information
Presented to The Kansas House of Representatives
Energy and Natural Resources Committee

from:

Patrick A. Craig, Assistant Manager/Hydrogeologist
Southwest Kansas Groundwater Management District No. 3

March 14, 1990

The Southwest Kansas Groundwater Management District No. 3 includes all of Morton, Stevens, Seward, Stanton, Grant, Haskell, Gray and Ford Counties and parts of Meade, Finney, Kearny and Hamilton Counties in Southwest Kansas. Approximately 5,380,500 acres of total land is included in the District. The average annual precipitation ranges from fifteen (15) inches in the west to about twenty (20) inches in the eastern part of the District. The entire District is included in the Kansas portion of the Arkansas River Basin. The District can be further subdivided into the upper Arkansas unit and the Cimarron unit. The principal source of water is groundwater. Most of the area overlies water bearing formations ranging in thickness from less than 50' to over 600'. The major water bearing formation is the Ogallala aquifer. Some wells in the district obtain water from the consolidated bedrock aquifers which include the Dakota, Cheyenne and Upper Jurassic aquifers, or from alluvial deposits along streams and valleys. In 1988 approximately 1,853,737 acres were irrigated in the District from 9,884 wells. Irrigation accounts for about 98% of the water use in the District.

The District's Revised Management Program was approved by the Chief Engineer-Director, Division of Water Resources, State Board of Agriculture, on May 26, 1989. The objectives and purposes of the District can best be accomplished by a combination of programs directed towards orderly and economical development, wise use, and responsible management of water. These will include the investigation of quantity and quality of water presently available; efficient use and management of existing water; and the identification of and subsequent development of potential sources of water to increase or maintain the supply. The Management Program includes the following. 1.) Geological Data Collection and Study 2.) Research and Education on the Conservation and Efficient Use of Water 3.) Conservation Planning 4.) Water Quality Protection 5.) Water Appropriation Rights 6.) Waste of Water 7.) Well Equipment Standards 8.) Weather Modification 9.) Feasibility of Imported Water.

The following is a more in depth look at some sections of the Revised Management Program:

Research and Education on the Conservation and Efficient Use of Water

- Continuing research is needed to develop techniques to optimize yields while minimizing water use. The District will encourage research on efficient and economical use of water.
- The District is currently cooperating with the Southwest Research Station, Kansas State Experiment Station, on the effectiveness and use of Low Energy Precise Application Technology (LEPA)
- The District has expanded the quarterly newsletter to include all land owners of partials greater than 40 acres. This allows better dissemination of important water issue information and education.

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ATTACHMENT 3

Water Quality Protection

-The District acknowledges that most legislative authority and responsibility of administration water quality protection programs rest with the Kansas Department of Health and Environment and the Kansas Corporation Commission. However, the District, through a spirit of cooperation, believes it should assist these agencies in their efforts to maintain water quality.
- The District has worked to involve local units of government in water quality protection efforts.
- The District has established memorandums of understanding with appropriate State agencies, thereby allowing a cooperative working relationship.
- The District has developed standards and policies, in concert with the appropriate State agency, to enhance enforcement and/or monitor rules and regulations.
-The District has established a quality monitoring network.
-The District is active in locating and re mediating abandoned water wells.

Water Appropriation Rights

- New Applications for additional appropriation over 5 acre feet are subject to well spacing and aquifer depletion criteria (High Plains aquifer). Well spacing criteria is dependent upon the quantity of water on the application. Aquifer Depletion criteria does not allow further development to occur in any area (2 mile radius circle) when depletion is greater than 40% in 25 years.

- At the request of the District, the Chief Engineer, on September 29, 1986, declared an Intensive Groundwater Use Control Area be established along the Arkansas River throughout the District and west of the District to the State line. The order of the Chief Engineer effectively closed the area to further appropriation, with the exception of domestic wells and new appropriations of 5 acre feet or less.

The Board of Directors voted to approve a proposal, as a resolution at the February 14, 1990 meeting. The proposal contained the following management alternatives, and additions to policies.

1.) Close all new appropriations, except term, temporary, and applications for less than 5 acre feet, in townships that are presently over-appropriated. This would not include applications that propose tapping the confined Dakota sandstones or domestic wells.

2.) Require meters on all non-domestic wells , and jointly with the Division of Water Resources, assist them in the proper enforcement of water rights.

3.) Enhance the Waste of Water Program .

4.) Work closely with the State Board of Agriculture in the administration of the chemigation law.

TESTIMONY TO THE KANSAS HOUSE OF REPRESENTATIVES

FROM

KEITH LEBBIN, MANAGER
WESTERN KANSAS GROUNDWATER MANAGEMENT DISTRICT #1

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ATTACHMENT 4

TESTIMONY TO THE KANSAS HOUSE OF REPRESENTATIVES

ENERGY AND NATURAL RESOURCES COMMITTEE

from

KEITH LEBBIN, MANAGER
WESTERN KANSAS GROUNDWATER MANAGEMENT DISTRICT NO.1
SCOTT CITY, KANSAS

MARCH 14, 1990

Mr. Chairman and Representatives. My name is Keith Lebbin, manager of the Western Kansas Groundwater Management District No.1. It is a pleasure to be allowed to speak to you today concerning the programs and operation of our district.

I would like to first inform you that our district is located in west-central Kansas. The areas included are portions of Wallace, Greeley, Wichita, Scott and Lane counties. There is slightly over one million acres within the boundary of our district as well as approximately 2900 large capacity wells. These wells are principally used to irrigate approximately 391,000 acres. The board of directors is comprised of five board members which are elected for a three year term at the district's annual meetings. Our board presently has a wide variety of members ranging from the mayor of the city of Leoti, a city councilman from Tribune, to board members primarily dryland operators, as well as ones who principally irrigate.

Our district operates under a management program which is approved by the Chief Engineer of the Division of Water Resources. This management program includes the programs and policies to be carried out in the district. These programs involve items such as: A) Operational Weather Modification, B) Developmental Programs, C) Water Quality Programs, D) Tailwater Control, E) Water Conservation Planning Assistance, F) Water Level and Discharge Measurements, G) Water Rights Administration and User Assistance, H) Cooperative Programs with State and Federal Agencies and I) A Proposed Metering Program. The management program is submitted to other water related agencies for their input and advice.

WEATHER MODIFICATION PROGRAM

In 1975 this district began the operation and management of district activities. Due to the declines in our groundwater levels, the district watched with a great deal of interest the experimental work which was being done by the Kansas Water Resources Board and the Bureau of Reclamation on a weather modification program in northwest Kansas. It was the general consensus that weather modification was a viable option for increased water supplies and that an operational program should be conducted, and should include the suppression of hail.

With this information in hand, our district initiated the first operational weather modification program in Kansas. The area included in this program was not only our groundwater district but most all of southwestern Kansas. Our District established a radar control site at the Kearny county airport in Lakin, Kansas and secured the necessary equipment to conduct the program. After fifteen years of operation, we now own four aircraft as well as a modern state of the art radar system.

This program operates typically from May 1 thru September 15 of each year. Agreements are annually obtained from each board of county commissioners to assist in the funding of the program. The annual budget is approximately $225,000.00. In order to conduct this program, we are required to obtain a permit and license from the Kansas Water Office and the state of Colorado. With the lack of state funding, there is no expertise at any state level. We are, however, required to submit start-up, bi-weekly, monthly, and final reports to the states.

There have been several outside evaluations on our program over the years. The first was conducted with funds provided by the Bureau of Reclamation, the second conducted by the state of Illinois funded by the National Science Foundation and the third and most recent, funded and conducted by the Bureau of Reclamation. These evaluations indicated an increase in rainfall of approximately nine percent and an average decrease in damaging hail of thirty five percent. When these figures are related to the savings in water, and in crop loss, it relates to something in excess of $100,000,000.00 's annually. Our District has also looked at the published hail insurance costs figures and compared the costs within our target area and outside of our area. We have found that the insurance rates are eleven percent less.

With these figures we are now entering the sixteenth consecutive year of operation. (Subject to approval by the Kansas Water Office.)

<u>DEVELOPMENTAL PROGRAM</u>

Our district also has a developmental program to control the development of our water resources. We are presently operating under a program based on the severity of depletion in the area. We are now proposing a modification in this program which would allow a one percent annual depletion rate. This program will be much more restrictive than the original program and for all practical purposes, will close the entire district to any new development. The district will reserve the right to review each application on its own merit and make the appropriate recommendation to the chief engineer. Available water rights in the area as well as the public interest will be considered.

WATER QUALITY PROGRAMS

A vital concern in our district is to maintain and protect the quality of our remaining water resources. During the past year, all wells, other than domestic, were visited and a determination of active or abandoned status was made. One hundred and twenty three abandoned unplugged wells were found. These individuals were notified that they either needed to properly plug the well, put it back into production, or place the well on an inactive status with the Kansas Department of Health and Environment. Plugging reports and state specifications are made available at the district office. The district has adopted Article 30 of the Kansas Department of Health and Environment as the program to follow.

This district also serves as a source of water analysis for the water users in the district. Sample containers are made available as well as instructions for obtaining a sample. The district is also in the process of establishing a network of wells to be annually monitored. This program should be initiated sometime this summer. We are also interested in working with the U.S.G.S. on a herbicide investigation in the near future.

TAILWATER CONTROL PROGRAM

In order to better manage and conserve the water resources in our district, we have initiated a tailwater control program. This district conducts field investigations to determine if a waste of water is occurring. If a violation has occurred, a notification is made to the water user notifying them of the violation and requesting immediate action be taken. If the violation continues, it then is the policy of the district to file a petition for a permanent injunction in district court. The requirements of the Kansas Irrigation Guide are made a part of the injunction. In this manner the conservation practices necessary to control the problem and increase irrigation efficiencies are in place.

WATER CONSERVATION PLANNING ASSISTANCE

Recently the district has begun working with applicants on the preparation of conservation plans. The district provides assistance in meeting the objectives of the State as a part of the filing requirements for a water right. This assistance applies to the municipal, industrial, and irrigation water users.

WATER LEVEL AND DISCHARGE MEASUREMENTS

As a service to the water users in the district, we do provide static water level measurement and well discharge measurement services. This better allows the water users to know the amount of water they are using and to monitor the water levels. These services are provided at no cost to the water user.

WATER RIGHTS ASSISTANCE

Another service this district provides is in the administration of water rights. As water users make changes in their operations, many change applications are required to be filed with the Division of Water Resources. Most of the work done in preparation for these changes as well as new applications is done in the district office. It is not at all uncommon to have to file four or five change applications when something is modified. As mentioned earlier, the conservation plan requirement on new applications is also being provided.

COOPERATIVE PROGRAMS WITH STATE AND FEDERAL AGENCIES

This district maintains a cooperative program with the U.S.G.S. on the preparation of data maps showing the percent decline since 1950 and the saturated thickness at the center of each section. There is also, as a part of this program, an additional nineteen water levels measured to fill the void created when the number of State wells was reduced. This information is used by the district in the development program outlined earlier. In the past we have also had cooperative programs with many other entities on a water management demonstration program and a groundwater recharge program. We have also had a one year cooperative program with the Ozark Regional Planning Commission on our weather modification program.

WATER METERING PROGRAM

The district is in the process of developing an acceptable metering program to be implemented in our district. We are considering such things as flow meters, hour meters, recent certified well tests, or some combination of the above. It is hoped that once a metering program is initiated, some type of water right reduction program can follow. One of the primary priorities in our district is a reduction in the amount of water which is being withdrawn.

ENVIRONMENTAL PROTECTION PROGRAM

This district has agreed to participate with the Northwest Kansas Groundwater Management District in the development of an environmental protection program. Meetings have been conducted with all of the county commissioners and county health boards in the development of this program. A local environmental planning board has been established and proceedings have been initiated to secure State Water Plan monies for the implementation of this program. Wayne Bossert will inform you in more detail on this program.

The district does not feel that any one program will solve our water decline problem. It is thought that a well developed program encompassing all of the above outlined programs will be the answer for our area.

The implementation of state policies are being routinely added to the operation of our district through the revision of the district's management program and rules and regulations. The district has entered into a memorandum of understanding with the Kansas Corporation Commission and the Kansas Department of Health and Environment. Other cooperative programs are conducted as the need and funding allow.

If there are any questions I would be more than happy to attempt to answer them. Thank you.

HIGH PLAINS IRRIGATORS' ADOPTION OF WATER SAVING-PRACTICES

Stephen E. White and David E. Kromm
Kansas State University

This summary provides some findings of survey research sponsored by the Ford Foundation on irrigators adoption of water-saving practices in 10 High Plains counties. 709 irrigators responded including 229 Kansas farmers in Finney, Thomas and Wichita counties. The objectives of the study are to identify and determine the frequency with which water-saving practices have been adopted by irrigators in the High Plains, and to discover those variables that are responsible for adoption variance.

CONSERVATION MOTIVES

* Most irrigators surveyed (89.4 percent) felt that they should voluntarily conserve groundwater, however, a significant majority indicated that low crop prices (68.1 percent) and energy costs (69.3 percent) are more important concerns than groundwater depletion.

* Less than half (37.1 percent) indicated that local, state, or federal governments should do more to encourage groundwater conservation.

* Almost one-half of the irrigators indicated that groundwater quality is a more important concern than depletion.

ADOPTION FREQUENCIES

* Only 3 practices among a list of 39 had been adopted by 50 percent or more of the irrigators (chiseling compacted soils, followed by irrigation scheduling, and reducing evaporation with stubble mulch).

* Several low cost and proven effective management practices such as monitoring soil moisture and metering water use were not adopted by at least one-half of the irrigators.

* Only four of the ten most adopted conservation practices were on the top-ten list of strategies that irrigators perceived as the most effective and significant water conservation tools.

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ATTACHMENT 5

FACTORS INFLUENCING THE ADOPTION OF WATER-SAVING PRACTICES

* The factor that best explains differences in adoption among irrigators is location. While the technologies to conserve water in the High Plains are generally available throughout the region the information base is not uniform and practices widely used in one area are almost ignored in other places.

* Other factors that influence adoption differences are type of irrigation system, number of irrigation wells, depth to water, age, and education in that order.

* Depth to water is more strongly associated with the adoption of water conservation strategies than low availability of water (saturated thickness of the aquifer). This suggests that conservation efforts may be driven more by economics (energy cost to pump water) than by fear of a declining aquifer or a pro-conservation ethic.

* A majority of irrigators adopted techniques that reduce water use primarily to conserve energy, reduce labor, increase yields, or replace existing equipment - not to conserve water.

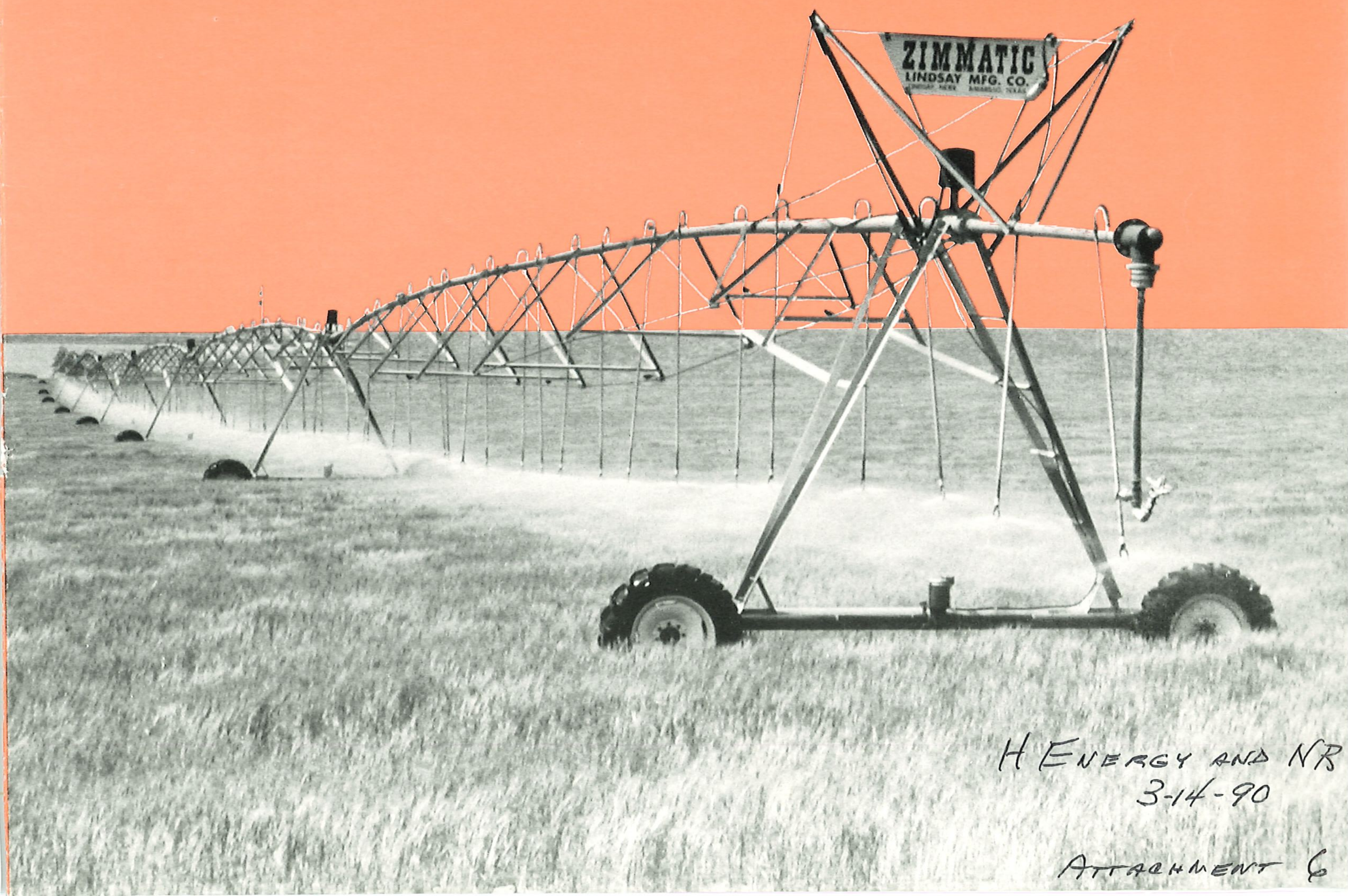
* The most commonly adopted practices are field and management practices that require a minimum level of investment. Capital intensive systemic practices that are perceived as most effective for conserving water are the least adopted.

SOURCES OF INFORMATION

* Kansas irrigators rely heavily on local, state, private and federal sources for information about water-saving practices. The four leading information sources are university research stations (43.1 percent), Soil Conservation Service (40.4 percent), local groundwater management districts (39.6 percent), and private agricultural consulting firms (37.3 percent).

CONSERVING WATER IN THE HIGH PLAINS

DAVID E. KROMM AND STEPHEN E. WHITE



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Attachment 6

INTRODUCTION

Irrigation in the High Plains is not a homogeneous activity. A wide variety of crops are grown, to include vast areas of cotton in the south and corn in the north, with much wheat, grain sorghum, and soybeans in between. Different methods of delivering water to the fields are employed. Both furrow and sprinkler irrigation are widespread. The techniques used to conserve water also vary. After observing conditions throughout the region for more than a decade, the writers wondered why certain water-saving practices were used in some areas and not others. We wondered also about the sources of information farmers relied on in deciding on how best to reduce water use. We were curious as to the patterns of diffusion for specific water-conserving practices. We were able to explore these issues with support from The Ford Foundation.

The High Plains study area extends over nearly 210,000 square miles in six states, ranging from Texas in the south to Nebraska in the north, and reaching into eastern New Mexico and Colorado (Figure 1). Some 10,400,000 acres are irrigated within the region, with most of the water coming from the High Plains aquifer (Figure 2). Sometimes this huge underground water supply, the continent's greatest, is termed the Ogallala, the name of its largest water-bearing formation. The High Plains aquifer refers to all the major groundwater sources in the region.

Depletion of the aquifer concerns residents and policymakers alike. High Plains farmers pump about 30 percent of all irrigation water pumped in the United States. As recharge is limited essentially to sandy areas and a few places where river water is applied to fields, for all practical purposes the aquifer is being mined. The water that is being taken out is not being replaced. The actual degree of depletion varies considerably because of great differences in amount pumped, recharge, and, most important of all, saturated thickness (Figure 3). As pumping reduces the saturated thickness, well yields can decline dramatically. Some wells go dry, and in others the remaining water is not economically recoverable. Overall, depletion is most advanced in Texas and least so in Nebraska, but individual farms throughout the entire region have had to abandon irrigation.

Figure 1

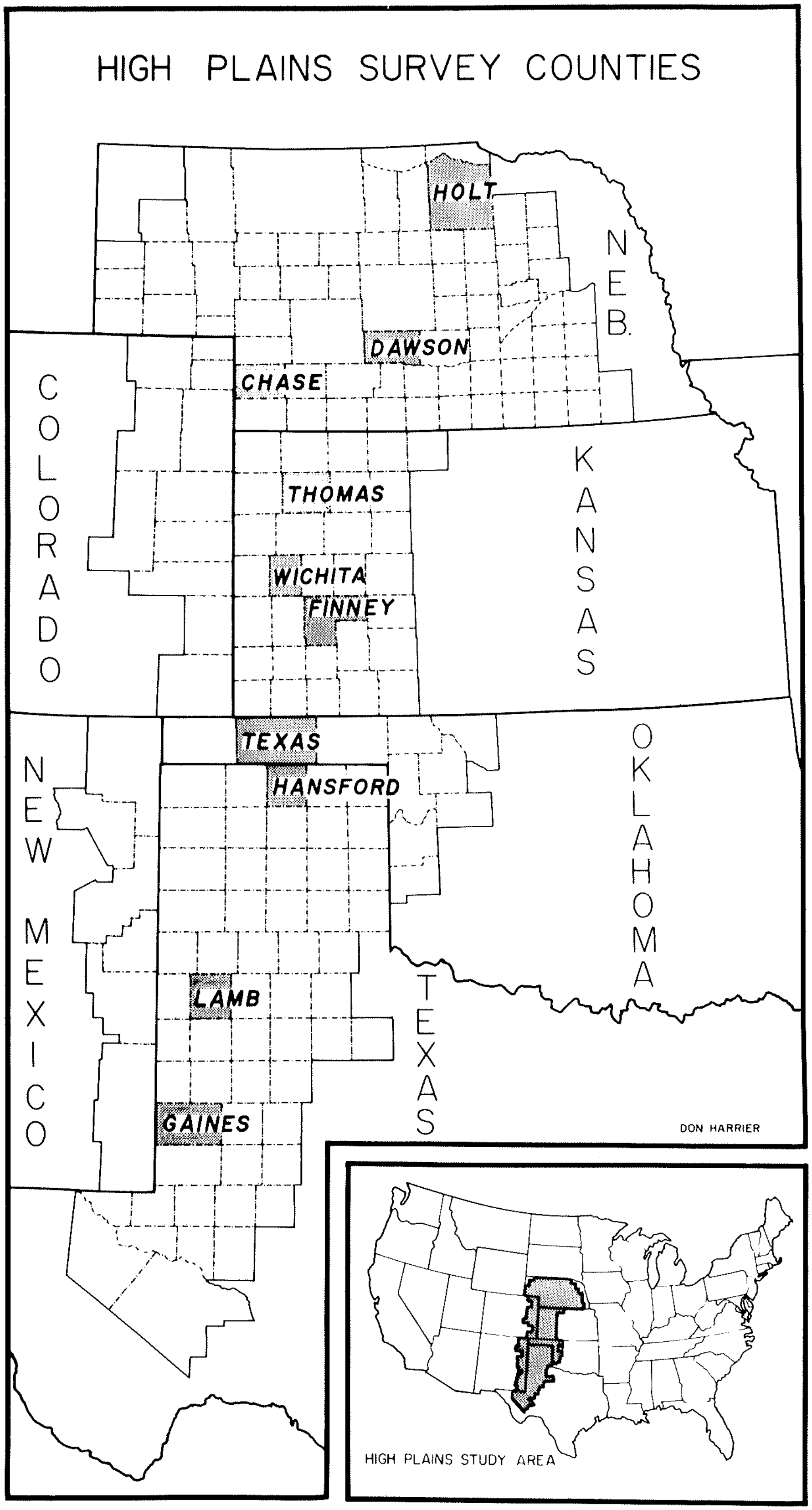

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Figure 2

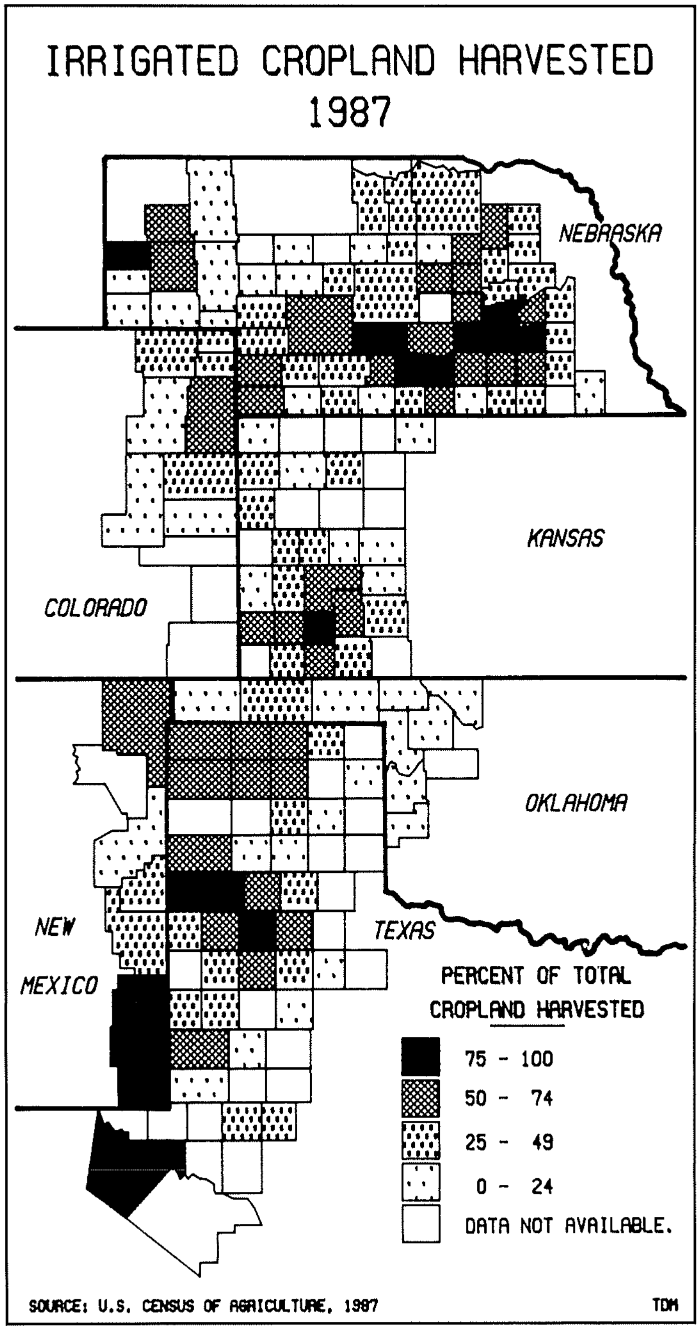
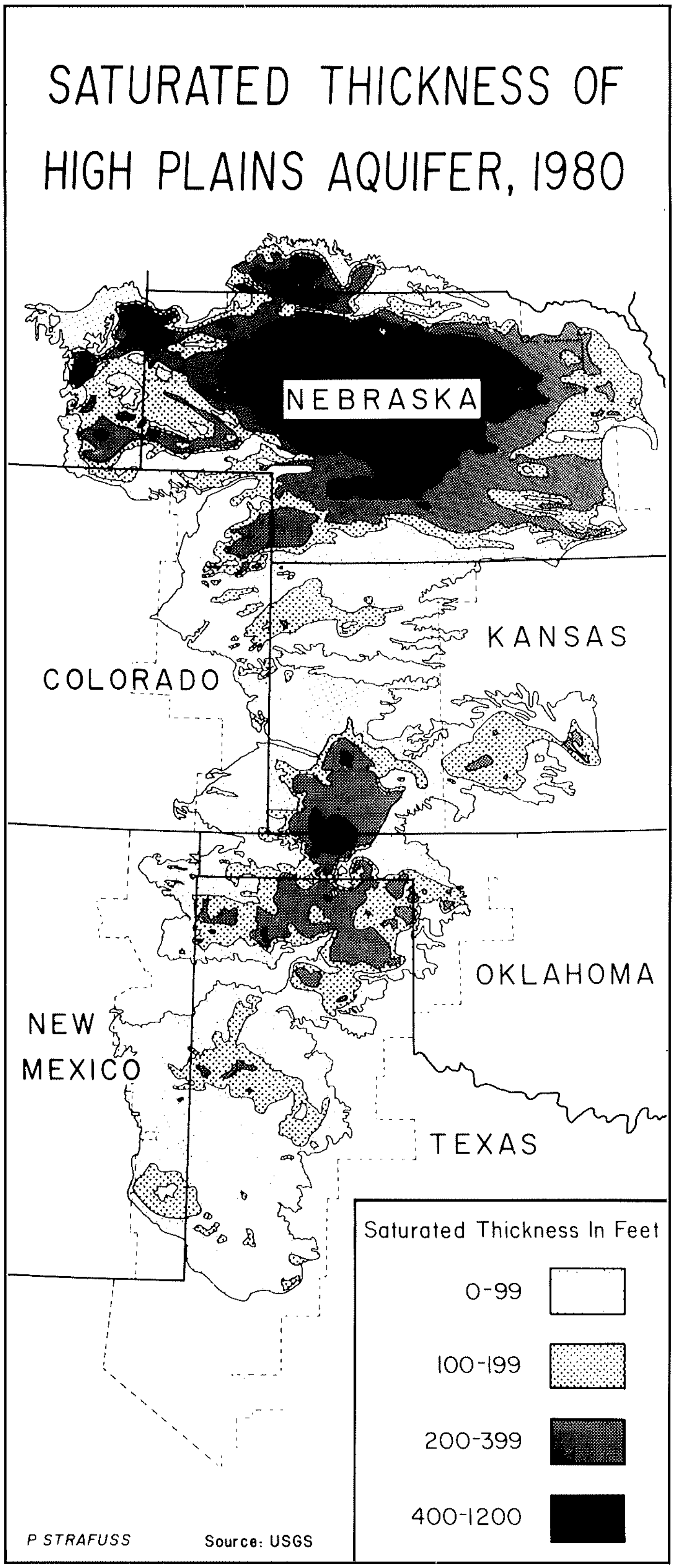


Figure 3



Map used with permission of the *Journal of Geography.*

Groundwater depletion is a critical issue in the High Plains because aquifers provide nearly all the water used by farmers and municipalities. There are very few rivers or lakes and precipitation is inadequate to support moisture-intensive crops or continuous cultivation. Aquifer depletion threatens the entire economy of the semiarid area. The irrigated feed grains are fed to cattle locally, and the cattle are processed regionally. It is an integrated agribusiness system based on irrigation. Take away the water and the whole economy would falter.

Four-fifths or more of the water goes for irrigation. If conservation to extend the life of the aquifer is to have any meaning it must occur in agriculture. Farmers are both the users of the water and the people most directly dependent on its continued availability. There is a built-in motivation to conserve. Fortunately, there are many practices, techniques, and devices that can be used to improve irrigation efficiency. Some are specific to the type of irrigation, such as surge flow, which is used in furrow irrigation, and drop tubes, which are employed with center pivot sprinkler systems. A few of the practices work best with certain soil or slope conditions or crops. Still, the adoption pattern for water-saving practices varies far more than these differences. Why is this so?

We focused our research on ten counties in four states. From south to north, the counties are Gaines, Lamb, and Hansford in Texas; Texas in Oklahoma; Finney, Wichita, and Thomas in Kansas; and Chase, Dawson, and Holt in Nebraska. They were chosen because of their high levels of irrigation, varied physical environments that are representative of the range of natural conditions in the High Plains, and familiarity because of previous research completed by the writers.

The data presented in this report were collected from published and unpublished materials, personal interviews, and a questionnaire that was completed by irrigators between September 1988 and March 1989. A sample of 1,750 irrigators, 175 from each one of the ten counties, was drawn systematically from lists prepared by local, state, and federal agencies operating within the area. A total of 709 farmers returned the completed survey instruments, giving an overall response rate of just over 40 percent.

The survey instrument asked questions to describe the respondents (age, sex, education, etc.), to determine the character of the farm (acres, tenancy, crops, livestock, etc.), water and irrigation (depth to water, saturated thickness, type of irrigation, number of wells, etc.), sources of information regarding irrigation management and specific water-saving practices, water conservation strategies adopted, and reasons for using or not using additional water conservation methods (Table 1). This publication reports on key findings from the questionnaire responses and provides a glossary of important terms related to groundwater and irrigation.

Table 1

Selected Characteristics of Respondents

Category	Frequency	Percent of Total
Age		
20–34 years	73	10.4
35–54 years	272	38.9
55 or more years	355	50.7
(missing 9)		
Education		
Less than high school diploma	89	12.8
High school diploma	240	34.5
Post high school training	177	25.5
College degree	189	27.2
(missing 14)		
Gender		
Male	648	95.0
Female	34	5.0
(missing 27)		
State		
Nebraska	254	35.8
Kansas	229	32.3
Texas	164	23.1
Oklahoma	62	8.7
County		
Dawson (NE)	101	14.2
Wichita (KS)	88	12.4
Holt (NE)	79	11.1
Thomas (KS)	79	11.1
Chase (NE)	74	10.4
Finney (KS)	62	8.7
Texas (OK)	62	8.7
Gaines (TX)	60	8.5
Lamb (TX)	57	8.0
Hansford (TX)	47	6.6
Irrigation system		
Gated pipe	272	39.4
Sprinkler	240	34.7
Gated pipe and sprinkler	153	22.1
Other	26	3.8
(missing 18)		
Number of irrigation wells		
1	109	16.0
2–4	270	39.7
5 or more	301	44.2
(missing 29)		
Depth to water table		
1–99 feet	223	36.1
100–199 feet	251	40.6
200 or more feet	144	23.3
(missing 91)		
Tenant		
Yes	227	36.4
No	396	63.6
(missing 86)		
Livestock		
Yes	349	51.1
No	334	48.9
(missing 31)		
Knowledge of water law		
Familiar	352	51.9
Somewhat familiar	285	42.0
Not familiar	41	6.1
(missing 31)		
Source of energy for pump engine		
Natural gas	307	46.9
Electric	93	14.2
Diesel	69	10.6
More than one source	185	28.3
(missing 55)		

WATER-SAVING PRACTICES

Thirty-nine water-saving practices were identified, and irrigators were asked to indicate each of the practices that they had adopted. The final list of practices included in the survey was based on a review of the research literature and field interviews with irrigators, water managers, and researchers throughout the High Plains. Preliminary lists were reviewed by county agricultural agents, SCS personnel, and water managers for completeness and accuracy of terminology, and several modifications were made.

The water-saving practices can be classified into three categories: field practices, management strategies, and system modifications. Field practices include actions that keep water in the field, more efficiently distribute a limited supply of water across the field, or encourage the retention of soil moisture. Examples include chiseling compacted soils and furrow diking to prevent runoff, leveling land to distribute water uniformly, and using ridge till or minimum till to retain soil moisture. Field practices are water-saving techniques that often do not require a large amount of capital for adoption.

Management strategies, unlike field practices that require modifications to the land, are attempts to monitor and gain information that helps in making decisions about scheduling water application or improving the efficiency of the irrigation system. Measuring rainfall, measuring soil moisture, checking pumping plant efficiency, utilizing agricultural consulting firms, and irrigation scheduling are management strategies designed to help an irrigator make the appropriate water application decisions.

System modifications are water-saving practices that require an addition to or an alteration of an existing irrigation system or the adoption of a new system. They require the purchase of equipment and usually cost more money than the adoption of field practices and management strategies. System modifications include adding drop tubes to a center pivot system, retrofitting a well with a smaller pump, the installation of a surge irrigation system, or the construction of a tailwater recovery system.

Presented with this wide range of water-saving methods, only three practices were adopted by at least 50 percent of the irrigators: chiseling compacted soils, irrigation scheduling, and reducing evaporation with crop residue (Table 2). Chiseling is also a soil conservation and residue management measure, so it is not clear just how important the water conservation motive is in its adoption. Eleven other practices were adopted by at least 25 percent of the irrigators. Focusing on the 15 most adopted water-saving practices, seven were management strategies, six were field practices, and only two were system modifications that required a greater level of investment.

Table 2

Water-Saving Practice Adoption Frequency

Rank	Water-Saving Practice	Percent Adoption	Practice Type
1.	Chisel compacted soils	66.8	Field
2.	Schedule irrigation based on moisture need	53.2	Management
3.	Reduce evaporation with stubble mulch	50.7	Field
4.	Employ minimum tillage	46.3	Field
5.	Monitor soil moisture	45.8	Management
6.	Practice preplant irrigation	44.4	Management
7.	Measure rainfall	44.0	Management
8.	Check pumping plant efficiency	44.0	Management
9.	Plant drought tolerant crops	43.5	Management
10.	Level land	42.2	Field
11.	Replace open ditch with underground pipe	37.5	System
12.	Use alternate furrow irrigation	36.7	Field
13.	Install tailwater recovery system	35.3	System
14.	Practice limited irrigation	27.8	Management
15.	Use inter-furrow ripping	23.9	Field
16.	Install low pressure heads on drop tubes	23.7	System
17.	Use private consulting firm	23.7	Management
18.	Retrofit well with smaller pump	23.4	System
19.	Meter water use	22.6	Management
20.	Compact furrows to speed stream advance	22.4	Field
21.	Reduce irrigation acreage	22.4	Management
22.	Replace old or leaking underground pipe	19.9	System
23.	Use low energy precision application (LEPA)	18.5	System
24.	Convert from furrow to sprinkler irrigation	17.9	System
25.	Use surge flow irrigation application	17.3	System
26.	Use ridge till	15.1	Field
27.	Use multi-function irrigation system	13.7	Management
28.	Use playas to supplement groundwater	13.5	System
29.	Use furrow diking	11.8	Field
30.	Build conservation bench terraces	10.7	Field
31.	Use no-tillage	10.2	Field
32.	Use skip row planting	9.3	Field
33.	Apply plant growth regulators	8.8	Field
34.	Use infrared canopy monitor	5.5	Management
35.	Use recharge well or basin	4.7	System
36.	Use drip irrigation	3.6	System
37.	Use hooded sprayers	2.6	System
38.	Use cablegation	1.7	System
39.	Recover water from air injection	1.5	System

As seen in Table 2, system modifications are adopted much less frequently than either field practices or management strategy type water-saving practices, even though many of the system modifications have proven to be very cost effective. For example, drop tubes can be added to a center pivot system for approximately $4,000 and significantly reduce evaporation and improve water distribution throughout the field. Some percentages appear low because the practice may only apply to either sprinkler irrigation systems or furrow irrigation. However, many practices apply to more than one type of irrigation system, and their lack of adoption is more difficult to understand. For example, metering water usage is a low-cost practice that is used by less than 23 percent of irrigators. Although 45.8 percent of irrigators indicated that they monitor their soil moisture, 56 percent of those indicated that they actually use the "feel" method, while only about 2 percent use gypsum blocks, and 5.6 percent use tensiometers. Over 26 percent use the services of a private consulting firm.

The seven least adopted practices are often considered experimental, evolving technologies, and it is not surprising that their adoption rates are not higher. However, our field experiences suggest that the level of awareness for plant growth regulators, infrared canopy monitors, hooded sprayers, and cablegation vary greatly from place to place. The diffusion of information to irrigators is not a uniform process.

The survey results suggest that farmers have elected to adopt water-saving practices that are not system-oriented or as costly as more labor-intensive field practices. More important, system changes are often designed to encourage both greater yield and efficient water use. Because they are capital-intensive, irrigators must often increase yields to pay for the investment. Many management strategies and field practices, however, do not necessarily require greater yields to make water conservation pay. Perhaps the more interesting questions are why the pattern of adoption for specific practices is so varied from place to place and what factors can be identified to explain these adoption differences.

This tailwater recovery system, near Montezuma, Kansas, collects runoff from either irrigation or precipitation. The tailwater can then be reused to irrigate crops more cheaply than groundwater, which must be pumped from the aquifer, thus conserving both water and energy. About 35 percent of irrigators surveyed use tailwater recovery systems.

Cablegation is found mainly in southwest Nebraska and northwest Kansas. The pipe is sloping downward, towards the bottom of the photograph, with the gates in the background no longer open and those in the foreground not yet open. Chase County, Nebraska.

Surge flow system showing pipes carrying water, and a solar-powered control box, which is programmed to open the gates on an intermittent cycle. Chase County, Nebraska.

REGIONAL VARIATION OF WATER-SAVING PRACTICES

Location is the factor most associated with the variance of irrigator decisions to adopt water-saving practices. We knew from previous research that irrigators in different parts of the High Plains were adopting different technologies, but we assumed that many of these variations could be explained by differences in aquifer characteristics, types of irrigation systems used, and socioeconomic characteristics.

The level of adoption for each of the 39 water-saving practices was crossclassified with each of 15 other variables producing a total of 585 tables. Chi-squared values were examined for each table. The six least used practices had too few adoptions to assume that the chi-squared values were statistically meaningful, so we eliminated them from our statistical analysis. When the 33 remaining practices were each crossclassified by county, 28 practices had chi-squared values large enough to indicate that their rates of adoption varied significantly at the .01 probability level (Table 3). Interestingly, when practices were crossclassified by state, only 21 practices showed significantly different levels of adoption at the .01 level. This suggests that many water-saving practices may vary more within states than between states.

We looked closely at differences among counties. Four practices that did not vary significantly (chiseling, irrigation scheduling, measuring rainfall, and checking pumping plant efficiency) are some of the more widely adopted practices throughout the High Plains, and only small differences from county to county were expected. Several practices, however, have tremendous adoption rate disparities for different counties. For example, 81.8 percent of irrigators in Chase County, Nebraska, meter their water use, whereas only 1.9 percent (one responding irrigator) in Texas County, Oklahoma, did so. Chase County is within a groundwater control area, and farmers are required to meter water use. Most do. In Gaines County, Texas, 70.7 percent of irrigators indicated that they were using drop tubes on center pivot systems, yet in Holt County, Nebraska, a county with a high concentration of center pivots, only 18.1 percent had installed drop tubes. Fifty percent of irrigators in Wichita County, Kansas, use limited irrigation, while only 7.6 percent in Chase County do likewise. Most Thomas County, Kansas, irrigators (61 percent) monitor their soil moisture, whereas only 21 percent of Hansford County, Texas, irrigators find it worthwhile to do so.

To see if county-to-county differences in level of adoption for certain practices could be explained by other factors, we performed a series of three-way crossclassifications. Each water-saving practice was crossclassified by survey county while controlling for the influence of other variables. The variables controlled included type of irrigation system, depth to the water table, number of irrigation wells, level of educational attainment, and age. When controlling for type of irrigation system, 25 of 33 practices still varied among counties at the .01 probability level. For example, if we focus on just irrigators who use sprinklers, we still find that this specific group adopts water-saving practices at significantly different levels in different counties. Likewise, the other four control variables explained very little about why intercounty variations are so strong.

If counties are ranked 1 through 10 on the basis of the frequency with which irrigators adopted a specific water-saving practice, an aggregate adoption index can be determined for each county by simply computing its mean rank value for all 39 practices. Such an index permits us to compare counties on the basis of how frequently irrigators have adopted water-saving practices "across the board." On this basis, Finney County, Kansas, appears to be the highest adoption county followed by Thomas, Hansford, Lamb, Wichita, Chase, Dawson, Gaines, Texas, and Holt. One interesting generalization appears when counties are ranked in this fashion. The top five adoption counties are each within a groundwater management district or underground water conservation district. The objectives of these districts are focused exclusively on groundwater management and conservation issues, and they all have professional staff that work closely with irrigators and provide information about groundwater conservation practices. There is no one local agency that is primarily concerned about groundwater issues in two low adoption counties: Gaines and Texas. Chase, Dawson, and Holt counties all rank as relatively low adoption counties. Each of these counties is within a Nebraska Natural Resource District that is responsible for managing groundwater. However, the NRDs have many other responsibilities beyond groundwater management, and it is not clear if irrigators perceive NRDs as having a mission to educate and encourage the adoption of water-saving practices. Although Chase ranks sixth on the aggregate adoption index, it leads all counties in the adoption of seven specific practices. This suggests that irrigators in counties that ranked lower may still be very concerned about saving water but that they focus on specific practices rather than adopting a large number of techniques.

Drop tubes on a linear sprinkler system, at the Texas A&M research station, near Etter. The pipe in the foreground carries the water flow from the well and moves with the system. Moore County, Texas.

Table 3

County Water-Saving Practice Adoption Frequencies

Water-Saving Practice	Gaines	Lamb	Hansford	Texas	Finney	Wichita	Thomas	Chase	Dawson	Holt	Differences Among Counties Sig. at .01 level
	Percent Adoption by County										
Chisel compacted soils	50.0	61.9	88.6	58.6	60.0	67.7	67.2	81.0	73.1	53.8	
Schedule irrigation based on moisture need	53.4	48.0	55.8	54.7	53.6	45.2	59.4	54.5	54.6	52.8	
Reduce evaporation with stubble mulch	27.6	46.0	65.1	49.1	60.7	61.6	52.2	66.7	43.3	40.3	*
Employ minimum tillage	19.0	34.0	37.2	34.0	64.3	46.6	42.0	57.6	61.9	50.0	*
Monitor soil moisture	41.4	26.0	20.9	35.8	53.6	46.6	60.9	59.1	52.6	43.1	*
Practice pre-plant irrigation	72.4	70.0	65.1	58.5	57.1	74.0	60.9	15.2	6.2	4.2	*
Measure rainfall	50.0	36.0	37.2	32.1	46.4	39.7	36.2	50.0	49.5	54.2	
Check pumping plant efficiency	31.1	44.0	53.5	39.6	55.4	49.3	46.4	56.1	33.0	38.9	
Plant drought tolerant crops	36.2	36.0	55.8	39.6	60.7	64.4	52.2	28.8	32.0	36.1	*
Level land	39.7	28.0	67.4	56.6	44.6	42.5	40.6	33.3	63.9	6.9	*
Replace open ditch with underground pipe	6.9	64.0	65.1	49.1	51.8	71.2	31.9	27.3	26.8	2.8	*
Use alternate furrow irrigation	5.2	50.0	39.5	20.8	44.6	58.9	52.2	34.8	48.5	5.6	*
Install tailwater recovery system	3.4	28.0	69.8	43.4	33.9	35.6	52.2	43.9	46.4	1.4	*
Practice limited irrigation	32.8	28.0	37.2	28.3	50.0	45.2	36.2	7.6	8.2	19.4	*
Use inter-furrow ripping	9.8	11.1	11.1	15.4	25.7	14.6	36.0	61.0	40.3	2.0	*
Install low pressure heads on drop tubes	70.7	38.0	16.3	18.9	37.5	2.7	47.8	3.0	3.1	18.1	*
Use private consulting firm	7.3	--	13.9	23.1	34.3	6.3	54.0	34.1	36.1	14.0	*
Retrofit well with smaller pump	46.6	40.0	32.6	24.5	28.6	38.4	13.0	15.2	8.2	5.6	*
Meter water use	19.0	8.0	14.0	1.9	23.6	15.1	37.7	81.8	12.4	8.3	*
Compact furrows to speed stream advance	3.4	54.0	41.9	30.2	41.1	38.4	11.6	7.6	14.4	2.8	*
Reduce irrigation acreage	10.3	22.0	46.5	28.3	30.4	57.5	27.5	6.1	3.1	8.3	*
Replace old or leaking underground pipe	39.0	22.2	44.4	25.6	25.7	25.0	14.0	7.3	6.9	6.0	*
Use low energy precision application (LEPA)	27.6	26.0	16.3	9.4	37.5	2.7	21.7	25.8	8.2	19.4	*
Convert from furrow to sprinkler irrigation	12.1	42.0	18.6	18.9	30.4	1.4	37.7	24.2	5.2	4.2	*
Use surge flow irrigation application	--	20.0	23.3	30.2	26.8	56.2	11.6	9.1	3.1	1.4	*
Use ridge till	3.4	14.0	14.0	3.8	14.3	21.9	13.0	9.1	40.2	1.4	*
Use multi-function irrigation system	20.7	10.0	2.3	5.7	19.6	2.7	15.9	34.8	4.1	20.8	*
Use playas to supplement groundwater	--	32.0	44.2	13.2	7.1	6.8	13.0	9.1	19.6	1.4	*
Use furrow diking	8.6	34.0	14.0	13.2	8.9	16.4	11.6	7.6	10.3	--	*
Build conservation bench terraces	5.2	12.0	14.0	5.7	19.6	20.5	21.7	3.0	7.2	--	*
Use no-tillage	6.9	6.0	7.0	5.7	14.3	6.8	11.6	13.6	18.6	5.6	
Use skip row planting	24.1	28.0	4.7	1.9	23.2	6.8	1.4	4.5	5.2	1.4	*
Apply plant growth regulators	51.7	22.0	7.0	1.9	7.1	2.7	2.9	3.0	--	1.4	*
Use infrared canopy monitor	--	2.0	--	--	7.1	1.4	13.0	18.2	--	11.1	*
Use recharge well or basin	1.7	8.0	--	1.9	5.4	2.7	8.7	3.0	10.3	1.4	
Use drip irrigation	3.4	6.0	4.7	1.9	5.4	4.1	8.7	1.5	--	2.8	
Use hooded sprayers	3.6	--	--	3.4	6.0	--	3.4	3.2	2.6	1.9	
Use cablegation	1.7	4.0	2.3	--	--	1.4	--	4.5	--	4.2	
Recover water from air injection	3.6	4.8	--	3.3	--	3.1	1.7	1.6	--	--	

OTHER FACTORS THAT INFLUENCE ADOPTION OF WATER-SAVING PRACTICES

In addition to locational differences, five other variables also are associated with adoption differences. They are, in order of importance, number of wells, type of irrigation system, depth to water, irrigator age, and educational attainment. Other variables that were crossclassified with water-saving practices but showed very little adoption differences among irrigators included saturated thickness of the aquifer, year when irrigation was first begun, sex, tenancy, owner/operator status, familiarity with state water laws, and livestock.

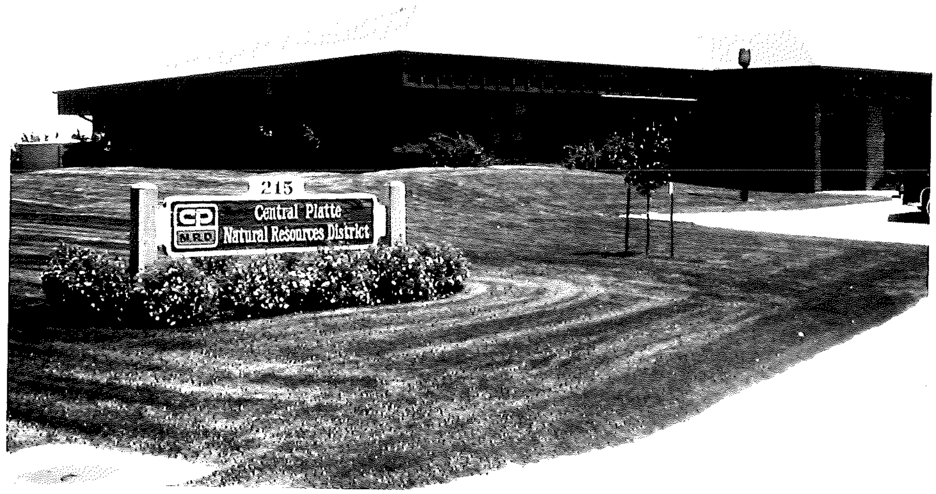
Water-saving practices were crossclassified with the number of wells operated by irrigators. Categories included one well, two to four wells, and more than five wells. Significant adoption differences emerged for 20 water-saving practices. Operators with more than five wells were much more likely to have become adopters for each of the 20 practices for which significant differences occurred.

Sixteen practices had significantly different adoption rates when crossclassified with type of irrigation system. This was not a surprising finding in that some practices such as surge and limited irrigation only apply to furrow irrigation while other practices like LEPA and drop tube installation are limited to sprinkler systems.

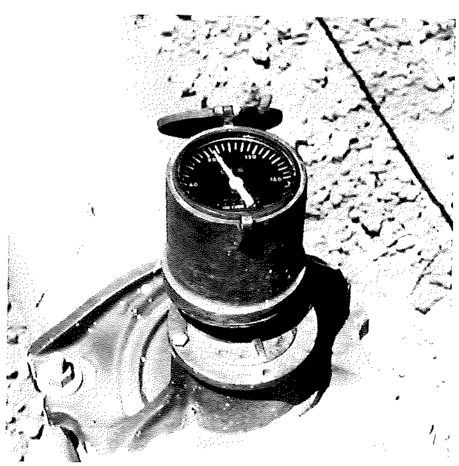
Depth to water equates to energy costs; the deeper the irrigator must drill to reach the water table, the higher are energy costs for pumping. Irrigators who had to lift water more than 200 feet to tap the aquifer were significantly more likely to adopt 13 practices than those who had better access to the water table. It appears that energy cost is a much more important consideration than the amount of water available to an irrigator as only three practices were significantly adopted more frequently by irrigators who had less saturated thickness than more fortunate respondents.

Younger respondents were significantly more likely to adopt 10 water-saving practices than were older irrigators. Likewise, irrigators with more educational attainment were more likely to adopt eight practices more frequently than those with less education. Interestingly, those practices that were adopted more frequently by irrigators with more education tended to be information-based management practices such as monitoring soil moisture, using private consulting firms, measuring rainfall, and checking pumping plant efficiency.

In summary, the variance in irrigator adoption of water-saving practices is primarily a function of location and secondarily influenced by number of wells, type of irrigation system, depth to water, age, and educational attainment of the irrigator. Locational differences remain strong even when the secondary factors are controlled. This suggests that adoption is not a uniform, easily generalizable process that can be quickly modeled and understood. Instead, it requires a greater understanding of the unique institutional and communication processes that exist at a local level. Likewise, efforts to encourage water conservation should be regionally specific. Broad-based programs designed to enhance water conservation at the interstate or perhaps even the state level must contend with a very complex mix of current water-saving practices.



The Central Platte Natural Resource District, headquartered in Grand Island, is one of 23 such districts in Nebraska responsible for managing local resources to include ground and surface waters. Districts are based on drainage basins. In Kansas, three groundwater management districts manage water use in the High Plains, whereas in Oklahoma, groundwater restrictions and policies are administered at the state level. Texas, like Oklahoma, has no legislative authority to manage groundwater at the local level; however, three underground water conservation districts conduct research and educational programs designed to help irrigators conserve water.



Metering water use is one effective and inexpensive management tool to control overwatering. Less than 23 percent of irrigators surveyed meter their water use. Texas A&M research station, Etter, Texas.

SOURCES OF INFORMATION

An important consideration in the use or nonuse of technology is the sources of information the potential adoptor relies on in making a decision. Innovations advocated by trusted sources are the most likely to be adopted. Who are the sources looked to for information in the High Plains? Three different items on the survey addressed this question. An open-ended question read "Identify your most reliable sources of information on how to most effectively manage your water use." Two later questions asked for the sources of information on the overall management of the irrigation system and the availability and practicality of specific water-saving practices and listed 13 possibilities. The percentage of irrigators selecting the 12 most preferred sources is given in Table 4.

The Soil Conservation Service ranks as the leading information source, with university research stations a close second. They were the only choices given as important by more than 40 percent of the respondents. For specific water-saving practices, they were followed by a group including University Extension Service, friends and neighbors, and local groundwater or resource district. For overall management, the secondary group was headed by local groundwater or resource district, private agricultural consulting firms, and University Extension Service. Interestingly, well drillers and fertilizer dealers were relatively important for overall system management, whereas irrigation equipment dealers were more important as an information source with respect to the availability and practicality of specific irrigation efficiency practices.

There was significant variation in the importance of information sources among the 10 counties. The Soil Conservation Service remained on top, ranking first or second for practices in seven counties and for overall management in five. University research stations were first or second in four counties for practices and three counties for management. Only the Soil Conservation Service was a leading information source in all four states. Local groundwater or resource districts, private consulting firms, and friends and neighbors round up the top five information sources in terms of county importance. Each ranked high in three counties for management and in two counties for practice.

The number of information sources indicated as important also varied significantly by county. In overall management, six different sources of information were used by 40 percent or more of the irrigators in Lamb and Dawson counties, with five sources having that level of preference in Texas and Holt counties. Only two sources of information for overall management were chosen by 40 percent or more of the farmers in Finney and Wichita Counties, and no source had that level of use in Gaines County. There was an even wider spread with respect to information sources for the availability and practicality of specific water-saving practices. Eight sources were widely used in Lamb County and five in Dawson County. Finney, Wichita, and Texas County farmers gave only two sources a high level of preference, and Gaines County again had none. About one-third of Gaines County farmers checked the Soil Conservation Service and irrigation equipment dealers for both overall management and specific practices. Overall, Lamb and Dawson County irrigators stood out as intense users of a wide range of information sources.

The reasons certain information sources are used more in one county than another are rooted in specific conditions almost unique to a given county. Local groundwater management districts established to promote water conservation are found in Kansas and Texas, where they are likely to assume some of the information-dissemination load met by state and federal agencies where local management agencies are not found. The natural resource districts in Nebraska have a broader mandate than groundwater alone, but they nonetheless also provide a local institution as a source of information and policy-making. The same agency frequently promotes different practices in different states and even counties. This is especially true of agricultural research stations and agricultural extension. Federal agencies are relatively more uniform in their programs.

Private firms offering consulting services and selling and repairing equipment are not evenly available throughout the High Plains. Access to a wide range of commercial agricultural services is best in more densely populated counties with at least one major town. Many counties have only the most basic of farm services. Individuals make a difference as well. An active, involved, friendly person who has the confidence of area farmers is likely to be sought out as an information source, irrespective of agency or firm affiliation.

Table 4
Important Sources of Information

Source	Irrigation System Management*	Water-Saving Practices*
Soil Conservation Service	45	45
University research stations	43	43
Local groundwater or resource district	35	34
Private agricultural consulting firm	35	33
University Extension Service	34	37
Friends and neighbors	33	36
Agricultural stabilization & conservation service	33	31
County agricultural agent	32	32
Well drillers	31	23
Fertilizer dealers	30	21
Irrigation equipment dealers	26	31
Trade magazines	22	24

*Percentage of respondents giving source as important.

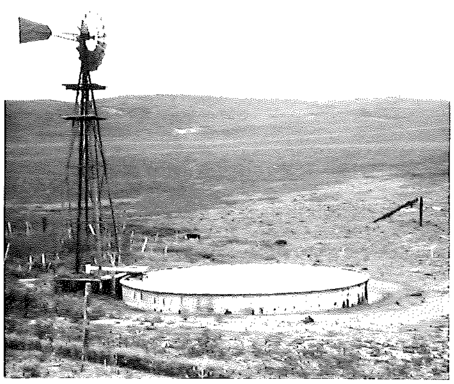
SUMMARY

The High Plains supports an integrated agribusiness economy based on pumping groundwater to irrigate more than 10,400,000 acres. Farmers in the region use about 30 percent of all irrigation water consumed in the United States. Most of the High Plains aquifer receives minimal recharge and groundwater depletion is taking place. As irrigators use more than four-fifths the regional water consumption, effective conservation of the aquifer begins with farmers. A wide range of water-saving devices and practices are available, and there are significant differences in the methods employed by farmers. This study reported the adoption patterns for water-saving techniques and information sources used by irrigators in Nebraska, Texas, Kansas, and Oklahoma.

Thirty-nine alternatives were identified and classified into three categories: field practices involving water retention and distribution, management strategies entailing monitoring moisture and collecting information to assist in achieving greater efficiency in water use, and system modifications that alter existing irrigation procedures or introduce new ones. Farmers significantly more preferred field practices and management strategies over system modifications. The 10 most widely adopted choices, all employed by more than 40 percent of the respondents, were field practices or management strategies. System modifications are generally more expensive and require the purchase of new equipment.

Location is the factor most closely associated with variance in adoption of water-saving practices. More than four-fifths of the widely adopted techniques varied significantly in terms of county. Other factors associated with adoption differences are number of irrigation wells, type of irrigation system, depth to water, age of irrigators, and educational attainment. The sources of information used by a farmer are important in the use or nonuse of a specific technology. Most relied on are the Soil Conservation Service and university research stations. With regard to choosing specific water-saving practices, university extension services, friends and neighbors, and local groundwater or resource districts are also important. For overall irrigation management other sources include local groundwater or resource districts, private agricultural consulting firms, and university extension services.

Irrigated agriculture in the High Plains is not a homogeneous activity. There are significant differences in the crops grown, the methods of applying water to the fields, the techniques used to conserve water, and the sources of information. The diversity is hidden because emphasis is placed on irrigation in a semiarid area as a source of regional unity. More revealing of the character of the area is the diverse way in which farmers manage the land and water resources. The High Plains is a region of striking contrasts.



The Nebraska Sandhills overlie the Ogallala aquifer where water is most abundant. Saturated thickness often exceeds 800 feet. Although rangeland is the dominant land use, irrigated agriculture occurs in some areas and is expanding.

Siphoning water from ditches to water corn is a labor intensive form of irrigation. Much water is lost by seepage through unlined ditches before the water reaches the field. Lamb County, Texas.

GLOSSARY

Acre-Foot: Volume of water required to cover one acre of land (43,560 square feet) to a depth of one foot; equivalent to 325,851 gallons.

Alternate furrow irrigation: Introduction of irrigation water into every other furrow between rows of a planted crop. Irrigation can remain in the same furrow, or furrows can be switched on subsequent irrigation. Alternate furrow irrigation can improve irrigation efficiency.

Aquifer: A water-saturated zone from which groundwater within can be obtained.

Base flow: Sustained low flow of a stream. In most places, base flow is groundwater inflow to the stream channel.

Cablegation: An irrigation method designed to save water that utilizes a plug pushed through gated pipe by water pressure that regulates the flow of water from the gates. Water is distributed to the field sequentially, several gates at a time, with watering time controlled by the rate at which the plug moves through the pipeline. Cablegation requires uniform side slope in the field.

Center pivot irrigation system: A sprinkler irrigation lateral that is mounted on wheeled structures (towers), anchored at one end (pivot point), and which automatically rotates in a circle when irrigating. The lateral can be equipped with any of a variety of sprinkler and spray nozzle configurations. Tower movement can be driven by water pressure, hydraulic pressure, or electricity. A typical center pivot has a one-quarter-mile radius and waters approximately 130 acres.

Chemigation: Injection of agricultural chemicals or fertilizer into irrigation water for distribution to farmlands through irrigation systems.

Compacted furrows: Soil compaction in furrows from tractor wheels or compacting implement attachments that smooth and firm furrows resulting in increased water stream advance rates, reduced infiltration, and improved irrigation application efficiency for furrow irrigation.

Cone of depression: A depression of the water level around a well or group of wells resulting from water being withdrawn.

Confined aquifer: An aquifer in which groundwater is confined under pressure by impermeable formations. Direct recharge from the surface is prevented by the impermeable layer. Also known as an artesian aquifer.

Conservation bench terracing: A series of earthen embankments spaced across the downhill slope of a field to contain runoff from the field and designed to spread water from natural slopes over levelled field areas behind the terraces.

Depth to water: The depth of the water table below the earth's surface.

Ditch irrigation: Providing water for irrigation by transporting it to the fields through canals.

Drip irrigation: A method of irrigation in which water is allowed to drip or trickle from perforations in a low pressure pipe (usually plastic and double-walled) placed alongside the base of a row of plants. The spacing of the perforations is designed to produce a wetted strip along the crop row or a wetted area at the base of each plant.

Drop tubes; drop nozzles: Flexible or rigid hoses or pipe that lower the discharge point of a nozzle below the main lateral of a center pivot to distribute water usually at low pressure between crop rows in order to reduce evaporation.

Dryland farming: A method of farming practiced in subhumid regions that incorporates various techniques of water-saving practices such as minimum tillage and summer fallowing. Dryland farming relies solely on growing season precipitation or water from precipitation stored in the soil profile during noncrop production periods.

Evapotranspiration: Water discharged to the atmosphere as a result of evaporation from the soil and plant surfaces and by plant transpiration.

Furrow diking: Installation of mounds of soil (dikes) in a furrow or installation of small depressions in the furrows to retain precipitation or irrigation water for crop use. It is a form of micro-catchment.

Furrow irrigation: Surface irrigation in which water is introduced at the high end of a field and flows downslope in furrows (small ditches) that are between crop rows.

Gated pipe irrigation: An irrigation system that delivers water to crops through a series of openings in a pipe placed at the upper end of a field. Gates are used to control the volume of water that flows from end openings into furrows.

Groundwater: Subsurface water in a saturated zone.

Gypsum block: A device used to measure soil moisture. It consists of a permeable ceramic gypsum cylinder about one inch long that is buried in the soil profile and connected to a resistance meter by a wire lead. Electrical resistance readings are related to soil water content.

High Plains Aquifer: A system of acquifers that underlies 174,000 square miles of the High Plains. It serves as the major source of water for irrigation in the High Plains of New Mexico, Texas, Oklahoma, Colorado, Kansas, and Nebraska, and extends into southeast Wyoming and southwest South Dakota.

Infrared canopy monitor: A sensor used to determine plant stress by measuring crop canopy temperatures.

Interfurrow ripping: A method of deep tilling in furrows using a chisel. The purpose is to break up the soil to allow better infiltration of water.

Irrigation scheduling: Procedure used in determining when to irrigate and how much water to apply to meet specific management objectives. There are several methods used to determine water needs, including: (1) water balance method, (2) stress-day index, (3) optimal sequencing of evapotranspiration deficits, and (4) measurements of leaf temperatures.

Irrigation withdrawals: Withdrawal of water for application on land to assist in the growing of crops and pastures or to maintain land for recreational use.

Limited irrigation: Irrigation scheduling method in which planned water deficits are allowed to occur generally on crops that are drought tolerant or with stages of growth that are less sensitive to water deficits. One example is fully irrigating only the upper half of a field. The next 25 percent is a tailwater runoff section that receives limited irrigation, and the lower one-fourth is a dryland section which may receive runoff from the upstream sections.

Low energy precision application (LEPA): Center pivot irrigation system that distributes water from an overhead lateral pipeline directly into furrows at very low pressure through drop tubes and orifice-controlled emitters. The purpose of this system is to apply water directly onto or near the soil to improve irrigation efficiency for systems with limited irrigation capacity.

Minimum tillage (limited tillage): Cultural practice that minimizes soil water loss, retains crop residuals to minimize soil erosion, and reduces tillage energy and labor requirements.

Multi-function irrigation system: Application of water-conserving chemicals such as antitranspirants, growth regulators, and soil surface evaporation suppressants. It is also used to apply fertilizer and pesticides and saves energy by requiring less tractor use.

Neutron probe: An instrument that measures soil water content by emitting "fast neutrons" from a radioactive source lowered into a tube placed in the soil. Neutrons colliding with hydrogen atoms in soil water are slowed and counted by the probe. This count is calibrated with soil water content.

No-tillage: Farming practice in which the soil is not tilled as a means of reducing soil water loss and soil erosion.

Ogallala Aquifer: The major aquifer within the High Plains aquifer system. It underlies 134,000 square miles of the High Plains and is comprised of alluvium deposited by ancient streams flowing east-southeast from the Rocky Mountains; consists of clay, silt, sand, and gravel capped by caliche.

Overdraft (mining of groundwater): Groundwater withdrawals in excess of recharge.

Plant growth regulators: Chemicals used to alter plant growth characteristics.

Playa: A depression in the soil surface without an outlet for runoff. It is covered with relatively impervious surface layers that inhibit water infiltration. A playa can be used to store runoff water for irrigation purposes.

Preplant (offseason) irrigation: Irrigation that occurs in the non-growing season of a crop to increase soil water availability.

Prior appropriation: A concept in water law under which users who demonstrate earlier use of water from a particular source are said to have rights over all later users of water from the same source.

Pumping plant efficiency: A measure of the actual amount of energy used for pumping water versus the theoretically required energy consumption.

Recharge: Addition of water to groundwater storage by natural processes or artificial methods.

Recharge dam: Dam built to capture surface runoff so water can percolate into an aquifer.

Recharge well: Well used to inject surface water into an aquifer.

Ridge tillage: Cultural practice of permanent ridge formation by tillage implements on which crops are grown. The purpose of ridge tillage is to maximize moisture retention while minimizing soil erosion.

Riparian rights: Concept of water law under which authorization to use water in a stream is based on ownership of the land adjacent to the stream.

Safe yield: Amount of groundwater that can be withdrawn from an aquifer without reducing the volume of water in the aquifer. Safe yield of an aquifer is equal to the recharge rate.

Saturated thickness: Vertical extent of the saturated zone as measured from its top to bottom.

Saturated zone: Subsurface zone in which all the interstices or voids are filled with water.

Skip row planting: One or more unplanted strips remain between planted rows in order to reduce crop water requirements.

Soil water monitoring: Various technologies that include tensiometers, neutron soil water meters, and soil water blocks that measure how much water is available in the soil profile. Soil water monitoring is required for irrigation scheduling.

Specific capacity: Discharge rate per unit of drawdown. Normally expressed as gallons per minute (gpm) per foot of drawdown.

Specific yield: The quantity of water that a unit volume of a material will give up when drained by gravity.

Stubble mulch: Residue left on the surface in order to control erosion and increase precipitation storage.

Surge flow: The intermittent application of irrigation water to irrigation pathways, creating a series of on and off periods of constant or variable duration in an attempt to improve irrigation efficiency. A microprocessor control unit temporarily opens and closes valves in gated pipe in order to discharge water in surges that achieve relatively even watering along entire length of row.

Tailwater recovery system: System to collect, store, and reuse irrigation and surface runoff. Water is collected in a tailwater pit where it can be stored and used to irrigate crops.

Tensiometer: Instrument that measures soil water tension. It consists of a tube with a porous tip that is filled with water and has an attached vacuum gauge. The tube is placed in the soil, and as water is lost from the soil, water is removed from the tube through the porous tip until equilibrium between soil water suction and tensiometer vacuum is obtained. The vacuum gauge then indicates soil water tension.

Unsaturated zone: Subsurface zone in which interstices are not filled with water; usually the interval between the land surface and the water table.

Water table: Top of the saturated zone in an unconfined aquifer. The water level in wells that penetrate the uppermost part of an unconfined aquifer marks the position of the water table.

House Energy and Natural Resource Committee
Irrigation Research in the Ogallala Aquifer Area
March 14, 1990

Testimony Prepared by
Hyde S. Jacobs
Director, Kansas Water Resources Research Institute

Introduction

Statewide, irrigators utilize 24,000 wells, irrigate 3.5 million acres annually and make 87 percent of the state's water withdrawals. About 63 percent (2.2 million acres) of that acreage is irrigated by gravity systems and 37 percent (1.3 million acres) by sprinkler systems.

In 31 western Kansas counties overlying the Ogallala Aquifer, approximately 5,000 irrigators use 17,000 wells and pump 2.7 million acre feet of water annually. Withdrawal generally exceeds recharge so conservation is critical.

Irrigation Research

In the Ogallala Aquifer area, irrigation research is conducted at the Northwest and Southwest Research-Extension Centers at Colby, Tribune, and Garden City. Outside the Ogallala area, irrigation research is conducted at the Kansas River Valley, North Central, and Sandyland Experiment Fields, and at Manhattan.

This report highlights selected research pertinent to irrigation in the Ogallala Aquifer area in western Kansas.

Use of Manure and Fertilizers

Manure and Nitrogen Trials: At Tribune, the yield of grain sorghum was increased 50 bushels per acre using 7.2 tons per acre of composted manure alone, or 55 bushels per acre using nitrogen fertilizer alone. The most effective treatment, however, combined both nitrogen fertilizer and manure and resulted in yield increases of 75 bushels per acre.

Phosphorous-Nitrogen Interactions: Research at Tribune demonstrated that irrigated corn and grain sorghum yields are increased by nitrogen and phosphorus but not by potassium fertilizer. Additionally, yields are not increased when phosphorus is applied without nitrogen. However, when nitrogen rates exceeded 120 pounds per acre, the use of phosphorous at a 40 pound per acre rate increased yields by 45 bushels per acre. The improved yield significantly enhances water use efficiency.

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Attachment 7

Irrigation Scheduling

Irrigation Scheduling for Corn: Research in 1982-1984 showed that a simple water budget, (using calculated evapotranspiration rates) could be used to schedule irrigation. The Northwest-Research Extension Center now reports evapotranspiration rates for farm use on a daily basis.

Subsequent research addressed the question: What irrigation sequence is best if water is severely limited?

When limited to 18 inches of water, the highest yield, 186 bushels per acre, was obtained by full irrigation. When limited to 12 inches of water, yields were reduced just 6 percent by supplying 75 percent of the calculated water need during the vegetative phase and using full irrigation thereafter. When limited to 6 inches of water, yields were reduced 29 percent by supplying 50 percent of the calculated need during the vegetative phase and full irrigation thereafter.

Irrigation Scheduling for Soybeans: During a three-year study, the irrigation requirement for fully irrigated soybeans averaged 13.1 inches annually; yields averaged 57 bushels per acre. By imposing moderate stress during the vegetative stage (75 percent of calculated water need), 1.5 inches of water was saved with only a 5 percent yield loss. Similarly, where stress during the vegetative phase was more severe (50 percent of calculated water need), 2.9 inches of water was saved with only an 11 percent yield loss.

Irrigation Scheduling for Sunflowers: Irrigation treatments ranged from no irrigation to rates supplying 140 percent of the calculated evapotranspiration rate during critical growth periods. The high yield treatment required 16.5 inches of irrigation subsequent to the middle of June. This irrigation rate (140 percent of calculated evapotranspiration rate) exceeds the design capacity of many systems and, therefore, is not very practical.

Irrigation Methods

System Comparisons: System efficiency varies greatly for different methods of irrigation. Gravity or furrow systems may be nominally 75 percent efficient, whereas sprinkler, low energy precision application (LEPA), and drip irrigation systems may be 85 percent, 95 percent and 99 percent efficient, respectively. We are conducting research with a variety of irrigation systems.

Surge Irrigation: With gravity irrigation, inefficiencies arise, because of runoff and because water and nutrients leach below the root zone at the head of the furrow long before water reaches the bottom of the row. Surge irrigation techniques were developed to reduce that loss.

K-State engineers utilize a computer controlled, wire telemetry system to automate gated pipe systems and facilitate surge irrigation. The system can control conventional gated pipe, surge systems, cut-back flows or power loads.

In surge irrigation systems, water surges or cycles down the row until the entire furrow is wet. The objective is to advance the wetting front rapidly and minimize infiltration. After the furrow is wet, flows are reduced to provide for uniform infiltration along the entire row.

Surge irrigation works best during preirrigation or the first irrigation of the season. Under those conditions, a 50 percent water savings can be realized. In subsequent irrigations, water advances rapidly along the row and the savings are much less.

Load Management: Load management may require excess generating capacity and is a problem for power companies. One cooperative, with help from K-State, instituted a successful power load management program. K-State made an extensive pump testing and irrigation scheduling program available to farmers. The Cooperative reduced rates, farmers saved money, and all irrigation pumps now are controlled centrally as part of a load management program.

Expert Systems: Similar load management systems have not been extended to other areas because irrigation scheduling principles are not generally understood and service companies do not provide irrigation scheduling services. Research is underway to develop an expert system that will manage such a service.

Low Energy Precision Application Systems: A low energy precision application system has been installed at the Southwest Research Extension Center. Crop yields from irrigation frequencies of 3, 6 and 9 days did not differ significantly. Yields increased steadily where water applied was 0.4, 0.7 and 1.0 times the evapotranspiration rate but leveled off thereafter.

Drip Irrigation Systems: With the aid of a USDA grant, experimental drip irrigation systems have been installed at Colby and at Garden City for use with corn and field crops. An interdisciplinary research team will study the system intensively to determine crop yield, water use, fertilizer efficiency and cost-benefit data.

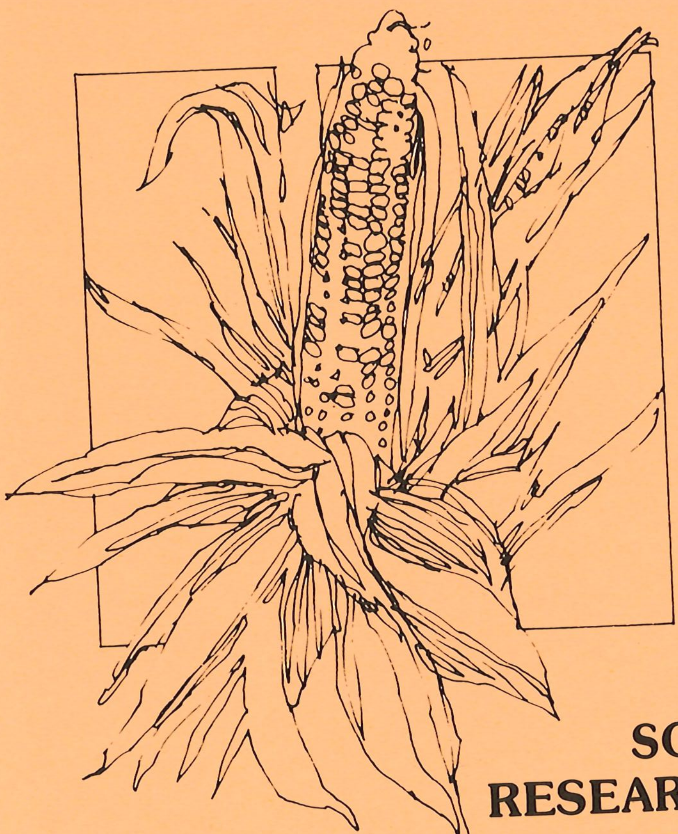
At Colby, the highest yield, 181 bushels per acre, was obtained with 15.5 inches of irrigation water. Reducing the irrigation application to 10.1 inches decreased yields by 3 percent. Drip irrigation systems are highly efficient and minimize the loss of both water and nutrients. Obtaining cost-benefit data will be an important part of the study because drip irrigation systems are expensive to install and maintain.

Off-Season Irrigation: Off-season irrigation (fall or spring irrigation prior to a summer row crop) is a management technique often used in western Kansas. Research at Tribune showed that off-irrigation is inefficient in many situations. For example, if fall moisture was 70 percent of field capacity, only half of the water added in the fall remains in the spring. Conversely, if fall moisture was 30 percent of field capacity, as much as 86 percent of the added water remained in the spring.

CORN-WATCH: Using water use data at Manhattan and Tribune, crop coefficients for corn were developed using thermal units. A computer program, CORN-WATCH, was written so farmers and specialists could project water use, growth stage and harvest date for hybrids of varying maturity. This facilitates hybrid selection where growth stage and water use patterns are management concerns.

Crop Selection: A linear programming model was developed to help farmers estimate land and water use depending on their net income or water conservation needs. Net income was highest where water use was highest. However, relatively large amounts of water could be saved with only a small loss in net income. Alternatively, the use of a water conserving crop mix could prolong aquifer life and increase net returns over the long term. Worksheets were published to help irrigators plan their crop mix.

1989 FIELD DAY REPORT



SOUTHWEST KANSAS RESEARCH-EXTENSION CENTER

Report of Progress 572 Agricultural Experiment Station
Kansas State University Walter R. Woods

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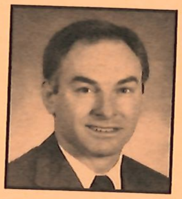
ATTACHMENT 8

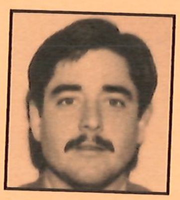


Jim Schaffer - Center Head. Jim received his M.S. and Ph.D. degrees from Kansas State University. He rejoined the staff in 1988. He served as Extension Agronomist from 1980-1983 and his research interests include crop production and management techniques.

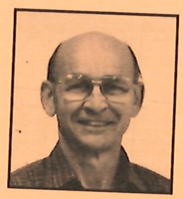
Ray Mann - Area Extension Director. Ray received his M.S. from Kansas State University. He became the Area Director for the first Area Extension Office in Southwest Kansas in 1969. Prior to that he served as County Agent in Wallace County and District Supervisor in Northwest Kansas.

Larry Buschman - Entomology - Corn. He received his Ph.D. from the University of Florida. He has previously worked with soybean and other insects in several states. He joined the staff in 1981. His research is mainly on the biology, ecology, and control of spider mites in corn.

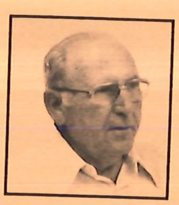
Les DePew - Entomologist. Les received his M.S. from the University of Minnesota and joined the Entomology faculty in 1954. His research has included pest management and bionomic studies on greenbugs, mites, weevils, and other insects in wheat, sorghum, alfalfa, and sunflowers.



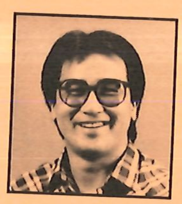
Steve Freeman - Animal Nutritionist. Steve received his M.S. from the University of Florida and his Ph.D. from New Mexico State University. He joined the staff in 1989. Research interests include effects of grain processing on nutrient digestion, health and nutritional management, and protein and fiber utilization by cattle.



Gerald Greene - Entomologist. He received his M.S. from Kansas State and his Ph.D. from Oregon State University. He was Station Head from 1976-1982. His research is on livestock entomology, with emphasis on control of stable flies by predators and parasites in feedlots of western Kansas.



George Herron - Soil Scientist. He received his M.S. at Oklahoma State and his Ph.D. from the University of Nebraska. He joined the staff in 1956 as Agronomist, with principal research interest in soil fertility and related areas of crop production. George was Station Head from 1982-1988.



Don Morishita - Agronomist - Weed Science. Don received his M.S. and Ph.D. degrees from the University of Idaho. He joined our staff in 1986. His research includes weed biology, physiology, and integrated management systems for weeds.

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Arthur S. Freeman...............Animal Nutrition
Larry Buschman..................Corn Entomology
Les DePew.......................Sorghum, Wheat, Sunflower Entomology
Kevin Dhuyvetter................Former Extension Agricultural Economist
Gerald Greene...................Feedlot Entomology
George Herron...................Agronomist
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Dwight Mosier...................Extension Crops and Soils
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Bill Spurgeon...................Water Management Scientist
Merle Witt......................Crop Production
Carol Young.....................Extension Home Economist
Andy Erhart.....................Professor Emeritus
Manjur Chowdhury................Research Associate

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Cargill Hybrid Seeds
Casterline & Sons Seed
CIBA-GEIGY
CONTISEED
Crow's Hybrid Corn Co.
Dahlgren & Co. Inc.
DeKalb-Pfizer Genetics
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ICI Americas Inc.
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NC+ Hybrids
Nickerson American Plant Breeders
NOR-AM Chemical Co.
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Oro Hybrids
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  -Wheat Commission
Stauffer Seeds Inc.
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Taylor-Evans Seed Co.
Tribune Compost Co.
Triumph Seed Co., Inc.
Uniroyal Chemical Co.
Wilson Blend
Wilson Hybrids, Inc.
W-L Research, Inc.

SW Research-Extension Center
Kansas State University

WEATHER AT GARDEN CITY

Charles Norwood

Precipitation totaled 11.52 inches (6.34 inches below normal), making 1988 the driest year since 1976 and the 9th driest since records were begun in 1908. Growing season rainfall (April-September) was 10.00 inches or 3.77 inches below normal. No significant rain occurred between June 1 and September 2. The greatest rainfall during these 3 months was 0.37 inch on July 19. September rainfall was 3.50 inches, resulting in good stands of wheat. However, the dry weather returned in October, with no significant precipitation in the remainder of the year. Snowfall for the year totaled 14.3 inches, and 7.5 inches of this occurred on January 6 and 7.

Dryland yields were reduced substantially, but irrigated yields were normal or even higher, because the dry weather was not accompanied by extreme heat. There was a total of 11 days of 100^{o}+ temperatures in 1988, but the only hot spell of any consequence was a period of 5 consecutive days of 100^{o}+ readings in June, including the high for the year of 105^{o} on June 23. Record high temperatures were 85^{o}, March 28; 80^{o}, November 15; 76^{o}, November 25; and 73^{o}, December 14. Record lows were -16^{o}, January 7 (also the low for the year); -13^{o} January 9; and 54^{o}, July 20. There were 6 days of 0^{o} or below minimum temperature, including 4 consecutive days from January 7-10.

Open pan evaporation was 73.61 inches or 4.71 inches below normal. Wind speed averaged 5.9 mph or 0.2 mph below normal. The frost-free period was 176 days (May 4 to October 28), compared to the average of 172 days (April 25 to October 13).

Table 1. Climatic data. Southwest Kansas Research-Extension Center, Garden City. 1988.

Month	Precipitation inches 1988	Precipitation inches Avg.	Temperature (°F) Maximum 1988	Maximum Avg.	Minimum 1988	Minimum Avg.	Mean 1988	Mean Avg.	Wind MPH 1988	Wind MPH Avg.	Evaporation inches 1988	Evaporation inches Avg.
January	.54	.35	36.2	41.5	10.7	13.9	23.5	27.7	6.5	5.1		
February	.04	.45	47.9	47.3	17.9	19.0	32.9	33.1	5.3	6.0		
March	.12	1.15	58.6	54.1	25.7	26.0	42.2	40.0	7.6	7.4		
April	2.08	1.42	65.4	66.7	35.0	38.3	50.2	52.5	6.8	7.7	7.76	8.79
May	1.98	3.26	78.5	75.8	50.9	49.3	64.7	62.5	8.5	7.1	11.88	10.96
June	.73	2.87	91.5	87.1	62.0	59.4	76.6	73.2	5.7	7.3	13.40	13.90
July	1.21	2.51	91.9	92.2	62.7	64.7	77.3	78.4	6.2	6.2	13.42	14.96
August	.50	2.19	92.0	89.5	62.5	62.6	77.2	76.0	4.7	5.5	12.72	12.78
September	3.50	1.52	79.6	81.0	52.4	53.9	66.0	67.4	5.5	5.7	8.68	9.80
October	.38	1.07	68.5	71.1	37.6	39.9	53.0	55.0	3.9	5.3	5.75	7.13
November	.44	.75	58.6	54.2	27.1	26.4	42.9	40.3	5.2	5.1		
December	T	.32	51.7	45.6	17.6	17.8	34.6	31.7	4.4	4.9		
Annual	11.52	17.86	67.7	67.2	38.5	39.3	54.2	53.2	5.5	6.1	73.61	78.32

Average earliest freeze in fall	Oct. 13	1988: Oct. 28
Average latest freeze in spring	April 25	1988: May 4
Frost-free period	170 days	1988: 176 days

[1]All averages are for the 30-year period 1951-1980, except for the October evaporation, which is the 1962-82 average.

WEATHER AT TRIBUNE

David Frickel

Precipitation of 1988 totaled 15.74 inches, 0.48 inches above normal (Table 1.). Precipitation was above normal in 5 months. The wettest months were May, with 2.81 inches, and July, with 3.08 inches of precipitation. The largest single amount of rainfall was 2.36 inches on May 31. Snowfall for the year totaled 27.45 inches. The largest single amount of snow was 14" on April 2.

Air temperatures were above normal for 5 months and below normal for 7 months. The warmest month was July, with an average temperature of 77.6^{o} F and an average high temperature of 92.7^{o}. The coldest month was January, with an average temperature of 20.6^{o}, an average high of 32.4^{o} and an average low of 8.8^{o}. Deviations from the normal were greatest in January, when the 20.6^{o} average temperature was 8.3^{o} lower than normal. The highest temperature was 102^{o} on July 14 and August 15. The temperature was 100^{o} F or above on 10 days (3 in June, 4 in July, 2 in August, and 1 in September). The lowest temperature was -18^{o} on January 7. There were 8 days with subzero temperatures. The last frost in the spring was May 4 (30^{o}) which was 2 days later than normal. The first frost in the fall was October 28 (24^{o}) or 20 days later than normal. The frost-free period was 177 days or 17 days more than normal. A record high temperature of 66^{o} was set on one day, December 18. Low record temperatures were set on July 21 (52^{o}) and August 29 (42^{o}).

Open pan evaporation from April through September totaled 81.33 inches or 15.57 inches above normal. Wind speed for the same period averaged 5.90 mph, compared to a normal speed of 5.64 mph.

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Table 1. Climatic data. Southwest Kansas Research-Extension Center, Tribune, 1988.

	Precip.[1] Inches		Temperature (° F)				Wind[2] MPH		Evaporation[3] Inches	
					Extreme					
Month	1988	Avg.	Avg. Max.	Avg. Min.	Avg. Max.	Avg. Min.	1988	Avg.	1988	Avg.
January	1.03	0.35	32.4	8.8	55	-18	4.17			
February	0.14	0.41	4.48	18.2	68	-2	4.42			
March	0.20	0.96	56.7	23.4	88	8	6.68			
April	1.63	1.37	64.2	31.2	85	23	5.38	6.80	8.91	7.79
May	2.81	2.67	77.5	45.7	94	30	7.54	6.30	15.18	9.96
June	2.17	2.74	88.7	58.9	100	45	5.13	5.75	16.62	12.46
July	3.08	2.51	92.7	62.4	102	51	5.41	5.06	16.33	14.21
August	1.48	2.20	91.7	62.7	102	42	5.98	4.96	14.03	12.18
Sept.	2.67	1.32	81.7	51.6	100	39	5.93	5.14	10.26	9.17
October	0.17	1.92	69.6	35.1	85	24	3.99			
November	0.08	0.51	57.7	25.6	79	11	5.26			
December	0.18	1.41	49.9	17.1	67	1	4.78			
Annual		15.74	16.38	67.1	36.7			5.61	81.33	65.77

Average earliest freeze in fall Oct. 8 1988: Oct. 28

Average latest freeze in spring May 2 1988: May 4

Frost free period 160 day 1988: 177 days

[1]Precip - 76 year period
[2]Wind - 65 year average
[3]Evap - 68 year average

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FIELD EVALUATION OF SEVERAL INSECTICIDES FOR SUNFLOWER MOTH CONTROL

Les DePew

Summary

One and two applications of four insecticides were evaluated for control of sunflower moth. All plots received an initial application on 13 July, 1988 when 30% of the plants were in the flowering stage. Plots receiving a second application were treated 5 days later. Larval densities were assessed 2 weeks after the initial application. All insecticides significantly reduced larval numbers below the untreated check with two applications and were effective with a single application, when sunflower moth pressure was light.

Introduction

The sunflower moth, Homoeosoma electellum (Hulst), is a damaging pest of cultivated sunflower in western Kansas. Adult females oviposit on the florets of developing inflorescences, and the eggs hatch into young larvae that soon tunnel into the maturing seed. It has been reported that one larva can damage an average of nine seeds during development. Feeding by the larvae not only destroys seed, but also contributes to secondary infection by a disease called Rhizopus head rot. This study was designed to evaluate larval control with one and two applications of several insecticides.

Procedures

This study was conducted at the SW Kansas Research-Extension Center near Garden City in a cultivated sunflower field planted to Hybrid 'SF100' on May 20. Plots were 4 rows wide by 40 feet long, with 5-foot alleyways separating blocks. Each treatment was replicated four times in a randomized block design. Plots were treated with a preplant application of Treflan to help control weeds, and postplant irrigations were applied to prevent moisture stress on the sunflower plants during the growing season.

Insecticides and application rates are given in Table 1. Test chemicals were mixed with water and applied as sprays with a CO_2-pressurized backpack sprayer calibrated to deliver approximately 11 gallons per acre. All plots received an initial insecticide application on 13 July, 1988 when 30% of the plants were in growth stage R5 (beginning of flowering). Plots receiving a second application were treated 5 days later. Only the two middle rows of each four-row plot were treated to minimize plot-to-plot contamination from spray drift. Densities of live larvae were assessed by dissecting five sunflower heads randomly selected from each plot 2 weeks after the initial spray application. Data were subjected to analysis of variance for significance, and Duncan's multiple range test was utilized to separate treatment means.

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Results and Discussion

Sunflower moth pressure was extremely light during 1988. All treated plots had significantly fewer larvae than the untreated plots (Table 1). Plots treated once with Karate, Asana, and Capture had significantly fewer larvae per head than plots treated with the methyl parathion standard, with no significant differences occurring between the three treatments. Methyl parathion gave the poorest control, but was significantly better than the check.

All plots receiving two applications of insecticides, had significantly fewer larvae per head than the untreated plots. Capture resulted in significantly fewer larvae than treatments with the methyl parathion standard. However, it did not differ significantly from Karate or Asana.

Experimental plots were not harvested for yield estimates because of low insect pressure and bird damage in the heads, which prevented reliable yield comparisons.

Table 1. Relative effectiveness of several insecticides for controlling sunflower moth on cultivated sunflower, Garden City, Kansas, 1988.

Treatment and formulation	Dosage (lbs AI/acre)	Mean no. larvae per 5 heads*	
		1 application	2 applications
Asana 1.9E**	0.025	1.7a (87)	0.7ab (95)
Karate 1E**	0.03	2.3a (82)	0.3ab (98)
Capture 2E**	0.02	2.7a (79)	0.0a (100)
M. parathion 4E	1.0	7.3b (44)	1.0b (92)
Untreated	---	13.0c (--)	13.0c (--)

*Means within the same column followed by the same letter do not differ significantly (P=0.05; DMRT). Percent control given in parentheses.

**These materials <u>DO NOT</u> have label clearance for use on sunflower and <u>CANNOT</u> be used on that crop. All are synthetic pyrethroids.

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SW Research-Extension Center
Kansas State University

EFFECTS OF NITROGEN LEVELS ON GREENBUG POPULATIONS IN GRAIN SORGHUM

Les DePew

Summary

A study was conducted to determine the effects of several rates of nitrogen fertilizer on abundance of greenbugs in grain sorghum. Generally, research has indicated a positive response to increased levels of nitrogen by certain insects. Greenbug numbers were very low in the treated plots, so it was impossible to obtain reliable assessments between fertilizer treatments.

Introduction

Variations in insect abundance on different crops have been attributed to various soil conditions, particularly fertility levels. In general, studies have indicated that the use of nitrogen stimulates the development and reproduction of certain crop pests. This situation may be due to the chemical composition of the plant sap, which, in turn, is affected by plant nutrition. This study was conducted to determine the effect of various nitrogen levels on field populations of the greenbug, _Schizaphis graminum_ (Rondani), on grain sorghum.

Procedures

This test was conducted at the SW Kansas Research-Extension Center near Tribune on Ulysses silt loam soil. The trial was superimposed on a fertility study being conducted by Alan Schlegel, agronomist-in-charge. Plots were arranged in a randomized block design with five replications. Individual plots were four rows wide (10 ft) by 60 feet long. Sorghum hybrid Golden Acres 'Dinero' was planted on 8 June, 1988. Fertilizer treatments monitored in this test were 40, 120, and 200 lbs N/acre applied broadcast as ammonium nitrate. Infestation records for greenbugs were made on 21 July and continued at biweekly intervals until 31 August, when conditions permitted. Insect counts were made by examining six plants selected at random from the two center rows of each four-row plot.

Results and Discussion

Greenbug numbers in the entire field, as well as the experiment site, were exceedingly low and variable. In general, most plants in the test plots were uninfested. If greenbugs were found, only one or possibly two plants were infested per plot. This condition existed throughout the growing season. Because of the low aphid densities and erratic infestation, it was impossible to make reliable assessments; thus, no trend between fertility rates was evident. Consequently, data are not included in this report.

SW Research-Extension Center
Kansas State University

FIELD COMPARISON OF DIFFERENT INSECTICIDES FOR CONTROL OF THE RUSSIAN WHEAT APHID ON WINTER WHEAT

Les DePew and Phil Sloderbeck

Summary

A study was conducted to determine the effectiveness of candidate insecticides for the control of Russian wheat aphid. Treatments were applied on 3 April, 1988 as broadcast sprays to wheat plants in the early-jointing stage of development. Aphid densities were evaluated by counting the number of insects on 20 stems selected at random in each plot. All insecticidal treatments caused a reduction in aphid numbers at each sampling date. In general, grain yields were increased, but not significantly so.

Introduction

The Russian wheat aphid, Diuraphis noxia (Mordv.), is a recently introduced pest of wheat and other small grains in Kansas. It was first identified from a wheat field in Stanton County in April, 1986. Since that time, it has been collected from 35 counties located in the western third of the state. The preferred hosts are wheat, barley, and triticale. The aphid does not appear to seriously damage oats or rye.

During feeding, a colony of Russian wheat aphids will cause leaves to begin showing symptoms of discoloration within 4-5 days. At about the same time, infested leaves may begin to roll together from the edges, giving a tube-like appearance. While feeding inside the folded leaf, the aphids are partly protected from natural enemies as well as from many insecticides. Data on insecticide effectiveness is limited in Kansas. Consequently, a field test was conducted to evaluate the efficacy of different insecticides and rates against the Russian wheat aphid in winter wheat.

Procedures

This study was conducted in a continuous dryland wheat field (cultivar TAM 107) located near Hugoton, Kansas. Plots measured 18 by 25 feet and were arranged in a randomized block design with three replications. Treatments (Table 1) were made on 13 April as broadcast sprays with a CO_2-pressurized backpack sprayer calibrated to deliver approximately 13 gallons per acre of total liquid. Wheat plants were in the early jointing stage of development at time of application.

Pre- and posttreatment insect counts were made immediately prior to treatment and at 2, 7, 15, 21, and 33 days after insecticide application. Russian wheat aphids were counted from 20 stems selected at random per plot. Stems were cut off at ground level, placed in plastic bags, and transported back to the laboratory for processing through Berlese funnels. Aphids extracted from the wheat samples were counted after 48 hours. Yield samples

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were collected by hand-harvesting all plants within four, 8-ft sections per plot (32 feet). Samples were threshed, grain was weighed, and yields were calculated in bushels per acre.

Results and Discussion

The Russian wheat aphid population at the time of insecticidal application was estimated to have infested approximately 20% of the plants in the immediate test area. Although the initial population appeared to be significant, severe plant damage never materialized as was originally anticipated. All insecticidal treatments caused a reduction in Russian wheat aphid densities below that of the untreated check during the 33-day evaluation period (Table 1). All dosage rates reduced aphid numbers below that of the check plots, but the lowest rate of each insecticide gave less control than did the higher rate of the same compound. However, only the lower rates of Karate and Asana did not differ significantly from the check plots. It should be mentioned that both rates of Asana were applied at dosages lower than recommended by the manufacturer because of a change in product formulation that resulted in a calculation error.

Significant yield differences among treatments did not occur, possibly because of large yield variations among plots. However, most insecticidal treatments provided higher grain yields than the untreated plots.

Acknowledgement:

Appreciation is expressed to Gary Gold, County Extension Agent, Stevens County, for helping to find a Russian wheat aphid-infested field for this study.

Table 1. Efficacy of several insecticides for Russian wheat aphid control in winter wheat, Hugoton, Kansas, 1988.

Treatment	lb(AI)/acre	Mean number of RWA*						Aphid days	Yield bu/acre
		Pretreat	Day 2	Day 7	Day 15	Day 21	Day 33		
Lorsban 4E**	0.50	20.7	1.0b (99)	0.3b (99)	0.0c (100)	0.0b (100)	10.3b (98)	109b	22.7
Lorsban 4E**	0.25	3.7	0.3b (97)	5.7b (44)	9.3bc (80)	7.3b (79)	25.3b (69)	433b	21.2
Disyston 8E	0.75	22.3	5.7b (93)	0.7b (99)	2.3bc (99)	6.7b (97)	51.7b (90)	621b	22.7
Asana 0.66E**	0.009	24.0	12.3b (85)	3.3b (95)	4.7bc (98)	0.3b (100)	64.0b (88)	736b	18.3
Penncap-M 2FM	0.75	18.0	4.7b (93)	5.0b (90)	7.7bc (97)	4.7b (97)	65.7b (84)	806b	20.4
Swat 8SL**	0.50	11.3	5.0b (87)	5.3b (83)	12.0bc (92)	8.7b (92)	67.7b (73)	900b	18.8
Karate 1EC**	0.03	8.7	4.3b (86)	2.3b (90)	3.7bc (97)	13.7b (83)	87.0b (55)	1062b	21.5
Karate 1EC**	0.01	41.0	10.0b (93)	3.3b (97)	4.3bc (99)	15.3b (96)	137.0ab (85)	1607b	20.0
Asana 0.66E**	0.004	24.0	33.0a (61)	6.0b (91)	58.7b (80)	50.3b (78)	135.3ab (75)	2408b	18.4
Check	---	14.0	49.0a	38.7a	174.7a	131.7a	312.3a	6080a	19.5 NS

*Means in a column followed by the same letter are not significantly different (P=0.05; DMRT). Percent control (corrected) using the Henderson-Tilton formula. NS, not significant.

**These materials are NOT registered for use against Russian wheat aphid on wheat and CANNOT be used for that for purpose.

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SW Research-Extension Center
Kansas State University

INSECTICIDE RESISTANCE IN GREENBUGS IN WESTERN KANSAS

P.E. Sloderbeck, M. A. Chowdhury, L. J. DePew and L.L. Buschman

Summary

Resistance to parathion and chlorpyrifos-methyl in two strains of greenbug was evaluated using a vial-residue bioassay technique. The tests, repeated three times over a 3-month period, detected resistance to parathion and chlorpyrifos-methyl in a greenbug strain collected from a parathion-failure sorghum field when compared to a 3-year old greenhouse colony.

Introduction

Resistance in greenbug, _Schizaphis graminum_ (Rondani), to several organophosphate insecticides including MSR, Di-Syston, and Cygon has been reported since the mid 1970's from Texas and Oklahoma. Recently, instances of failure to control greenbug with parathion and Lorsban (chlorpyrifos) have been reported from western Kansas.[1] It is suspected that insecticide resistance may have caused these control failures.

Procedures

During August of 1988, a greenhouse colony was established with greenbugs collected from a parathion-failure sorghum field in Meade County, Kansas. The greenbugs in this field had been treated twice with 1/2 lb ai/A of ethyl parathion. This colony was compared with a greenhouse colony established 3 years ago (designated as susceptible), using a vial-residue bioassay technique (see p. 14).

Resistance to both parathion and chlorpyrifos-methyl (a chemical similar to Lorsban) was evaluated. The bioassays were conducted three times (November and December, 1988 and January 1989). Five medium to large greenbugs were added to each vial. Each test was replicated six times. In the first test (Nov. 12), response (number dead) was recorded after 8 hours. In the 2nd and 3rd tests, the response (aphid incapable of coordinated movement) was recorded after 12 hours. Greenbugs from both colonies were tested using gel electrophoresis in March, 1989 to estimate levels of esterase enzyme. The gel electrophoresis study was conducted in cooperation with William C. Black IV and L. John Krchma at Kansas State University.

Analysis: The data were corrected using Abbott's formula and transformed to arcsine. The analysis of variance was applied to the data, to

[1]We thank Mr. Loarn Bucl (Production Advisory Service, Inc., Sublette, Kansas) and Mr. Jay Borth (Job Sprayers, Plains, Kansas) for alerting us to the greenbug control problem.

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test the effect of strains on the responses in aphids across all concentrations and replications. The means were separated using Duncan's new multiple range test.

Results and Discussion

In all tests, the proportions responding to test insecticides in the bioassays were lower in greenbugs from the parathion-failure field than those from the susceptible colony. Differences were statistically significant in the 1st and 2nd bioassays with parathion (Fig. 1) and the 1st and 3rd bioassays with chlorpyrifos-methyl (Fig. 2). These decreased levels of responses were exhibited several months after the last exposure to pesticides in the field. This suggests the presence of insecticide resistance in greenbug populations in western Kansas. This also indicates the potential of cross resistance, since the greenbugs from the prathion-failure field appeared to be resistant both to parathion and chlorpyrifos-methyl. The results of the bioassays were supported by the gel electrophoresis study that detected the presence of significantly higher levels of esterase in the greenbugs from the parathion-failure field. Increased levels of esterase are often associated with pesticide resistance in arthropod populations.

It should be noted that the results of this study are preliminary and were based on experiments with greenbugs from only one field. Therefore, before making any general conclusion regarding the presence of insecticide resistance in western Kansas greenbugs, a more extensive study needs to be done to determine the extent of the problem and to examine the chemicals that may be showing cross resistance.

Fig. 1. Response of resistant and susceptible greenbugs to parathion. Bars with the same letters on the same test date are not statistically different.

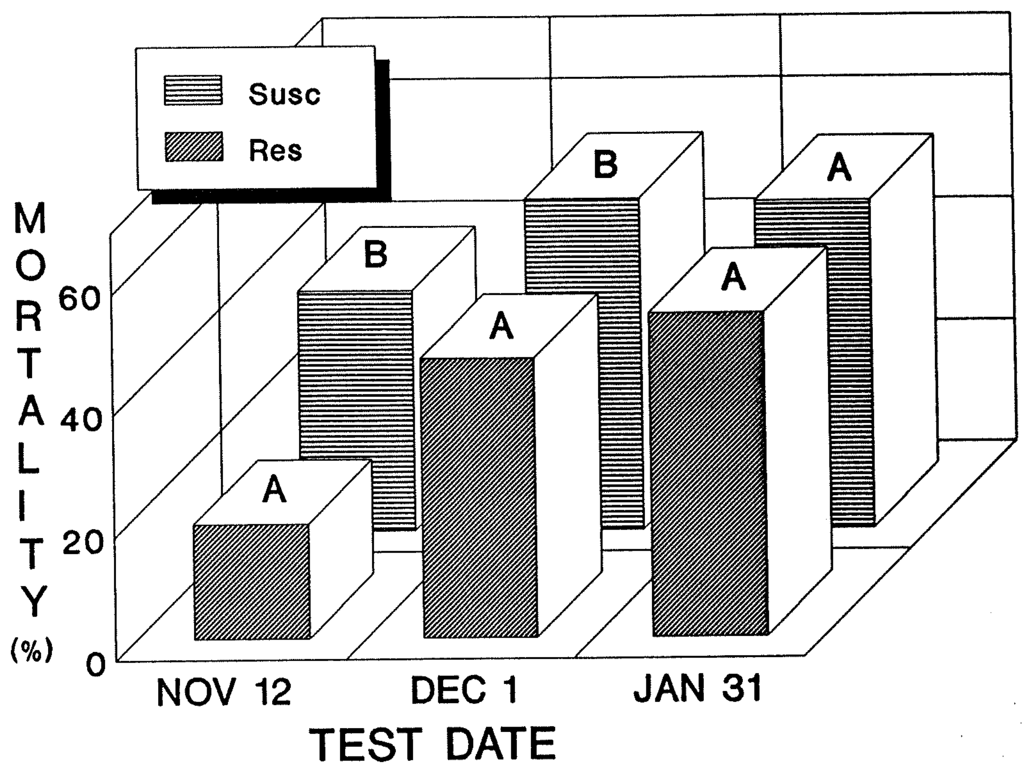
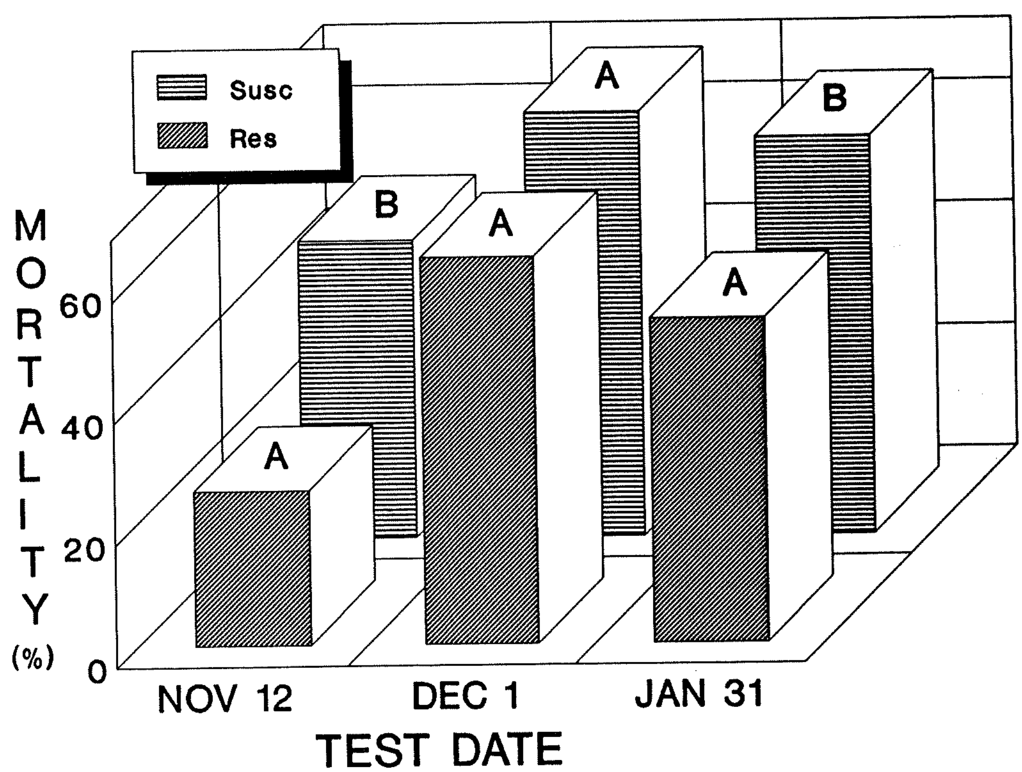


Fig. 2. Response of resistant and susceptible greenbugs to chlorphyrifos-methyl. Averaged across all concentrations. Bars with the same letters on the same test date are not statistically different.



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SW Research-Extension Center
Kansas State University

PESTICIDE RESISTANCE IN BANKS GRASS MITE POPULATIONS IN WESTERN KANSAS

M. A. Chowdhury and L. L. Buschman

Summary

Banks grass mite collected from pesticide-treated plots were tested (1986-88) to detect the presence of resistance to three acaricides: Cygon, Supracide, and Capture. A vial-residue bioassay technique was used to detect the resistance. Field-exposure to pesticides (except Lorsban) caused increased resistance to Cygon and Capture. In most cases, field-exposure to pesticides did not significantly increase resistance to Supracide. Mites with field-exposure to Supracide had high levels of resistance to Cygon and Capture.

Introduction

Infestations of Banks grass mite, Oligonychus pratensis (Banks), historically have been suppressed with applications of miticides. In recent years, an increasing number of miticide failures have been reported. These control failures may be due to resistance in Banks mite populations. This study was undertaken to determine if resistant Banks mite populations were increasing.

Procedures

A vial-residue bioassay technique was used to measure resistance to Cygon, Supracide, and Capture in Banks mite populations collected from pesticide-treated corn and sorghum plots. A series of 1-dram glass shell vials was coated (internal surface) with acetone dilutions made from technical Cygon, Supracide, or Capture. The doses added to the vials ranged from 0.001 to 1000.0 micro-gram per vial (spaced in a logarithmic scale). Ten, adult, female Banks mites were added to each vial, and vials were held in standard conditions for 24 hours. Mites were scored as dead if they failed to make any movement when probed with a fine brush.

Banks grass mites used in the bioassays were collected from plots of several miticide evaluation trials. In 1986, mites were collected from the following treatments in a small plot miticide trial in corn: Cygon, Supracide, Capture and the untreated check. In 1987, mites were collected from the following treatments in an aerial miticide test in corn: Capture, Furadan+Supracide, and the untreated check. Mites also were collected from the following treatments in an aerial test of greenbug insecticides in sorghum: Parathion, Lorsban, and the untreated check. In 1988, mites were collected from the following treatments in an aerial miticide test in corn: Capture, Furadan+Supracide, and the untreated check. The mites were collected 3 to 4 weeks after treatment application.

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Analysis: Percent mortalities were corrected using Abbott's formula. The corrected mortalities then were transformed to arcsine. Analysis of variance was applied to the data to test the effects of field exposure to pesticides on the mortalities across the concentrations and replications. The means were separated using Duncan's new multiple range test.

Results and Discussion

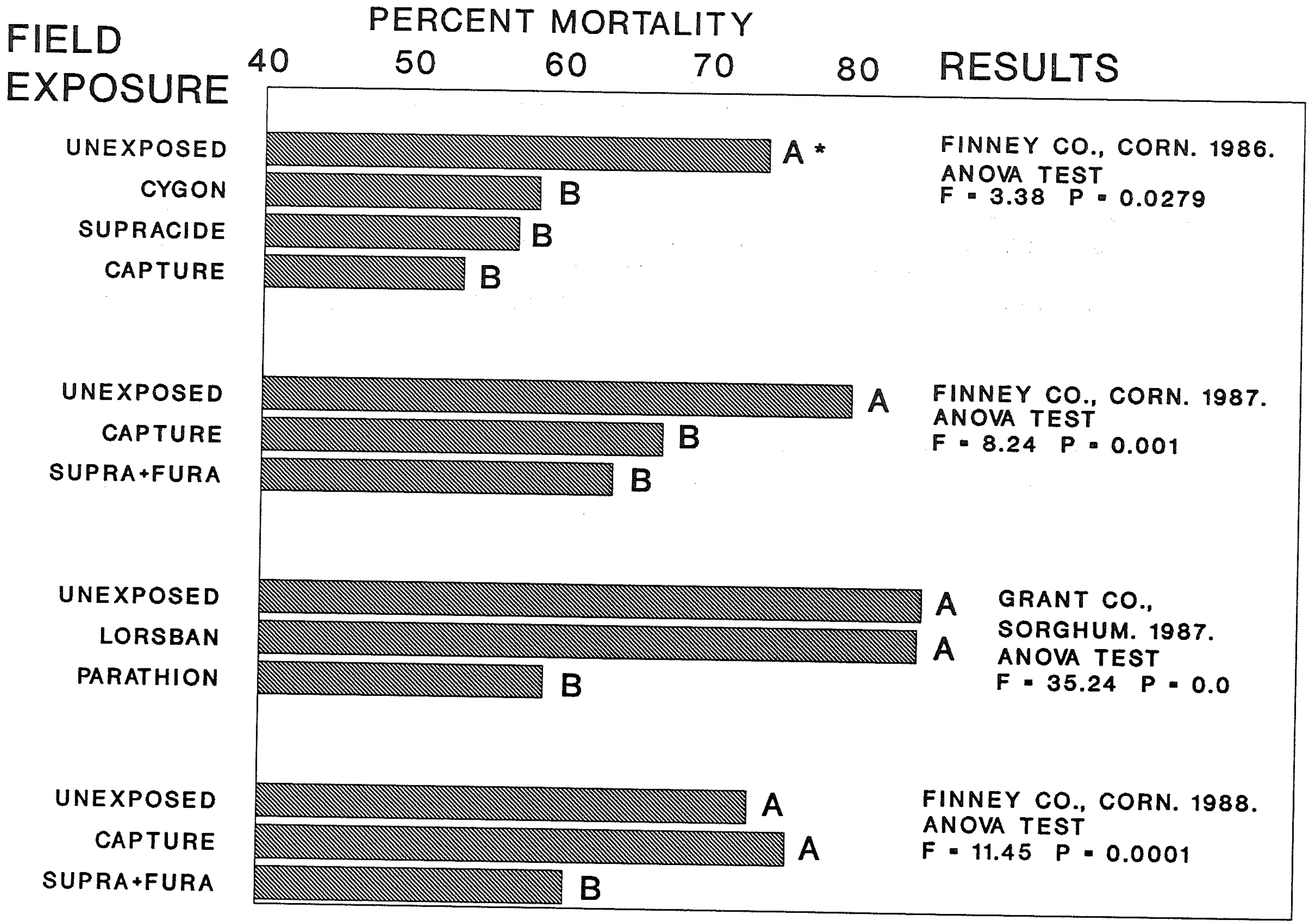
Cygon: In all four tests, mites taken from pesticide-treated plots had significantly lower mortalities to Cygon than did mites form the untreated check plots (Fig. 1). These reduced mortalities indicate the presence of resistance to Cygon. Mites collected from Lorsban-treated plots did not show resistance to Cygon. Mortality to Cygon for mites from Capture-treated plots were significantly reduced in the 1986 and 1987 tests but did not differ significantly from the check in 1988. Field exposure to Supracide or mixtures containing Supracide caused significant decreases in mite mortalities to Cygon.

Supracide: Only in the 1988 test, mites taken from pesticide-treated plots had significantly lower mortalities to Supracide than did mites from the untreated check plots (Fig. 2). These mortalities indicate that resistance to Supracide is not as strong as it is to Cygon. Mites from the Lorsban-treated plot had significantly higher mortality to Supracide than did mites from the untreated check. Field-exposure to Supracide or Supracide combinations caused high levels of resistance in the mites to Cygon (Fig. 1) and Capture (Fig. 3), but the resistance to Supracide was much less pronounced (Fig. 2).

Capture: Mites taken from pesticide-treated plots had significantly lower mortalities to Capture than did mites from the untreated check plots in several tests (Fig. 3). In three tests, mites field-exposed to Supracide or Supracide combinations had lower mortalities to Capture than did mites from check plots. Mortalities of mites taken from plots treated with Lorsban did not differ significantly from mortalities of unexposed mites.

The results of this study clearly indicate the presence of resistant Banks mite populations following single field exposures to pesticide treatments. The levels of resistance to Cygon and to Capture were the highest when mites had been field exposed to Supracide or Supracide mixtures. The susceptibility of BGM to Supracide was not changed much by field exposure to Cygon or Capture. This suggests that when multiple miticide applications are necessary in a field, the sequence in which the miticides are applied may be important. Application of Cygon followed by the use of Capture or Supracide may not be effective. However, Supracide may still be effective after pesticides have been used. The efficacy of a Capture application after other pesticides have been used is unclear at this time.

FIG.1. MORTALITY RESPONSE OF BANKS GRASS MITE TO CYGON.



* *Bars followed by the same letter in a test are not significantly (p=0.05) different.*

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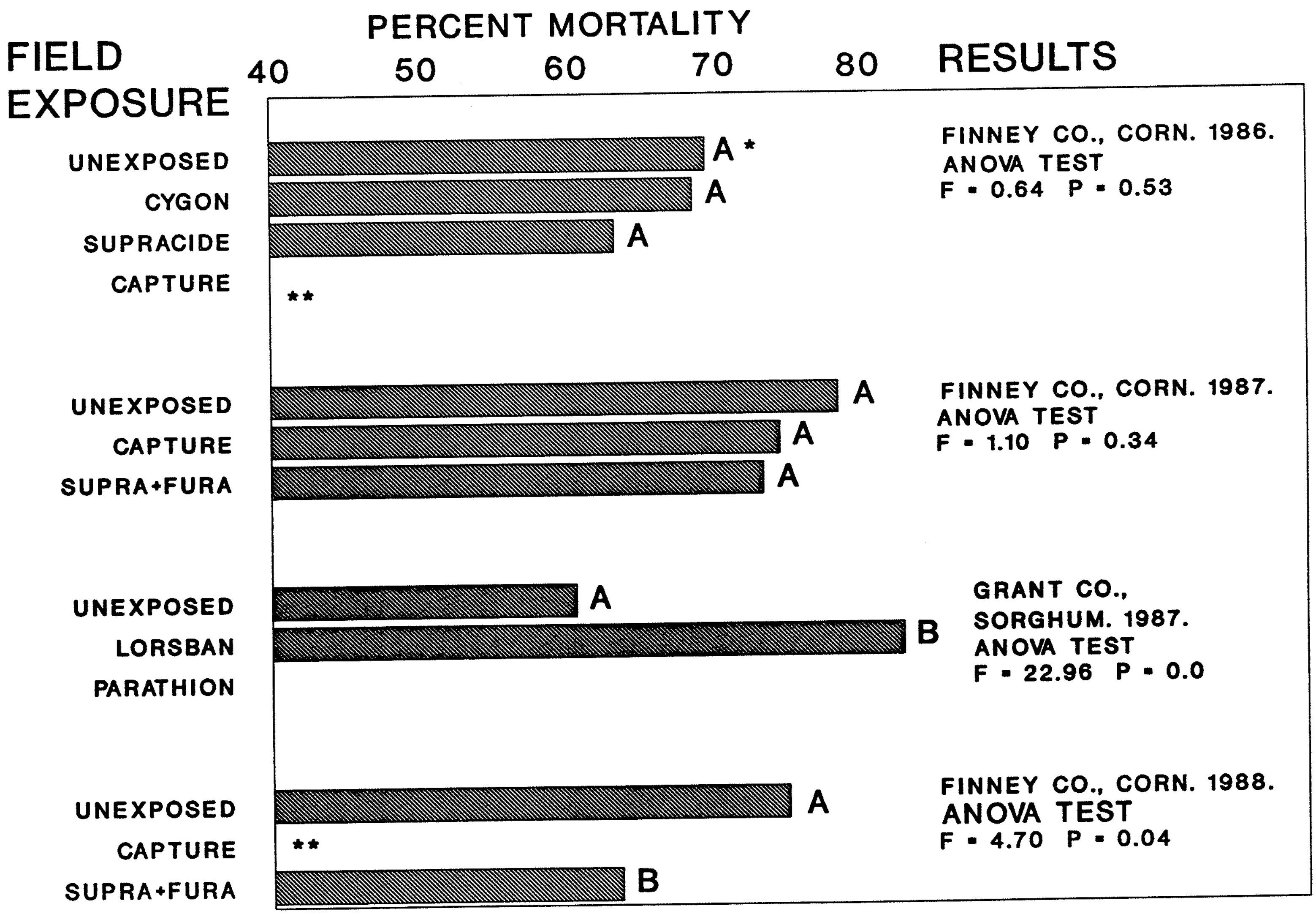
FIG.2. MORTALITY RESPONSE OF BANKS GRASS MITE TO SURPACIDE.



* *Bars followed by the same letter in a test are not significantly (p=0.05) different.*

** *High control mortality in bioassay.*

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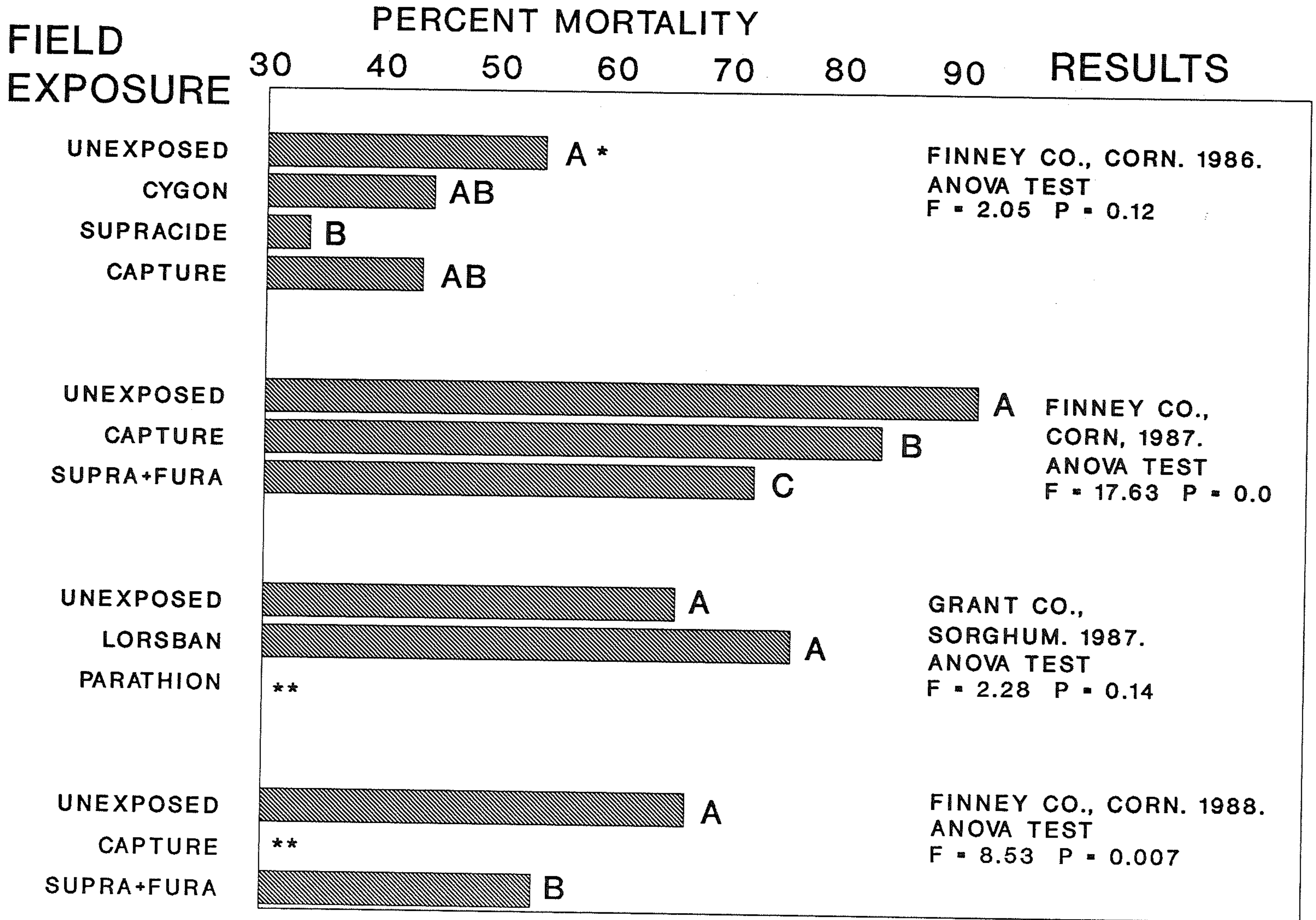
FIG.3. MORTALITY RESPONSE OF BANKS GRASS MITE TO CAPTURE.



* *Bars followed by the same letter in a test are not significantly (p=0.05) different.*

** *High control mortality in bioassay.*

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EFFECTS OF SOIL INSECTICIDES ON THE SUSCEPTIBILITY OF BANKS GRASS MITES TO MITICIDES

S.R. Sandoval, M.A. Chowdhury, L.L. Buschman, and K.L. Hernandez

Summary

Changes in the susceptibility of Banks grass mites after exposure to soil insecticides were evaluated. Mites were tested for loss of susceptibility to Cygon, Supracide, and Capture. The susceptibility of mites exposed to soil insecticides was reduced significantly when tested with Cygon, it was unchanged when tested with Supracide, and it increased significantly when tested with Capture.

Introduction

We have demonstrated recently that Banks grass mites (BGM), Oligonychus pratensis (Banks), exposed to single applications of pesticides in the field were less susceptible to miticides than unexposed mites. This study was conducted to determine if there was also a loss in susceptibility to miticides when mites developed on corn plants that had been treated with the soil insecticides normally used to control corn rootworms.

Procedures

The BGM colonies were maintained on corn plants in mite-proof cages with forced air ventilation. Care was taken at all times to avoid cross contamination of the mite colonies. Corn to maintain the spider mites was grown in a second greenhouse to avoid contamination with mites. Corn was grown in 100% vermiculite, with two plants per pot.

Trial 1. Six pots, with two 3-week-old plants per pot, were placed in each of four rearing cages. Measured quantities of soil insecticides were placed on the bottom of each cage to facilitate the absorption of the insecticides by the plants. The following soil insecticide treatments were added at rates calculated to be equivalent to twice the field rate based on the volume of potting medium: Furadan 10G, Dyfonate 20G, and Counter 15G; an untreated check was included. Equal amounts of water was added to the bottom of each cage. When the water was completely absorbed by the plants, two pots were removed from each cage and maintained in separate watering trays as extras to replace treated plants in the cages as they were consumed by the mites. Three days after the soil insecticides were applied, a plant heavily infested with BGM was added to each cage. The mites were taken from a one-year-old BGM colony, which was started from mites collected in Finney Co. KS. in 1987.

Trial 2. Four pots, with two 3-week-old plants per pot, were placed in each of nine rearing cages. Methods were the same as those described for trial 1, but only two insecticides, Furadan 10G and Counter 15G, were used.

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Bioassay: After the mite populations were large enough, they were bioassayed using a vial-residue bioassay technique with three miticides: Cygon, Supracide, and Capture. Each bioassay was replicated three times. Mortalities were recorded after 24 hours in a growth chamber. Vials with the mites were kept in a growth chamber under standard conditions and mortalities were recorded 24 hours later. Mites were scored as dead if they failed to make any movement when probed with a fine brush.

Analysis: The results of the bioassays were subjected to analysis of variance to test the effects of soil insecticide treatment on the mortality of BGM in the bioassays, across concentrations and replications. Single degree of freedom contrasts also were conducted for untreated check versus other treatments. For analysis, the data were corrected for control mortalities by using Abbott's formula, and the percent mortalities were transformed to arcsine values. The arcsine transformation of percent mortality was used in the analysis and back-transformed for presentation. Bioassays with control mortalities >20% were not included in the analysis.

Results and Discussion

After exposure to soil insecticides, BGM susceptibility to Cygon was significantly reduced (Fig. 1). Susceptibility of BGM to Supracide was not affected or was reduced only slightly (Fig. 2). However, BGM susceptibility to Capture was significantly increased after exposure to soil insecticides (Fig. 3).

In the analysis of variance of the two tests, the main effect of exposure to soil insecticides on BGM susceptibility to miticides was significant in each test, except for the second test with Supracide (Table 1). The single degree of freedom contrast for untreated check versus all soil treatments indicated that susceptibility to Cygon was decreased, susceptibility to Supracide was unaffected or only slightly reduced, but susceptibility to Capture was increased significantly as a result of exposure to soil insecticides.

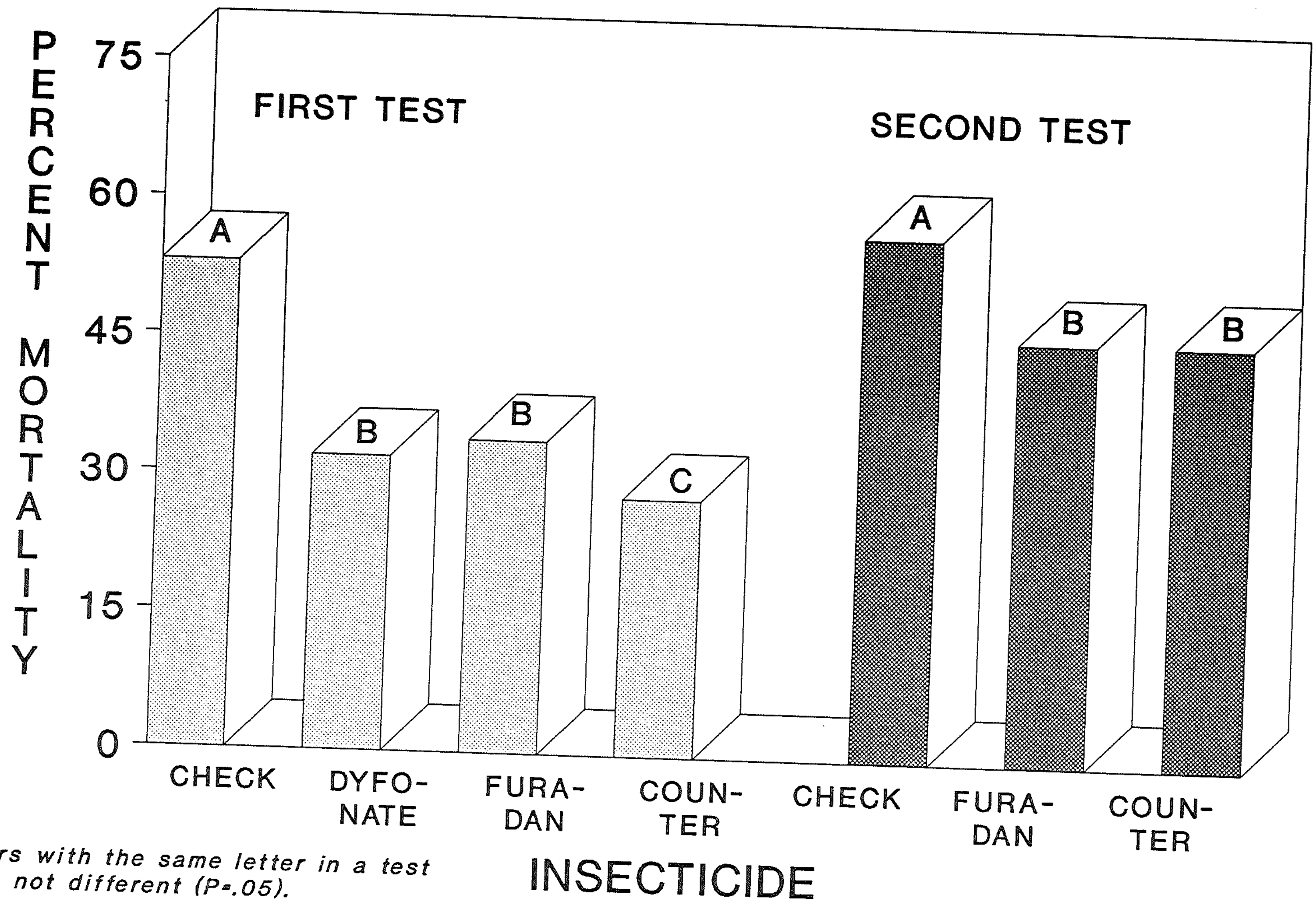
If these greenhouse observations are verified under field conditions, this may help explain the inconsistent performance of some miticides, such as Cygon. BGM susceptability to Supracide and Capture was not reduced by exposure to soil insecticides. We will need to pay much more attention to previous pesticide usage, including soil insecticides, in fields needing miticide treatments.

Table 1. Effects of soil insecticides on the susceptibilities of Banks grass mite to Cygon, Supracide, and Capture. First test-July; second test-December.

	Test Miticides														
	Cygon					Supracide					Capture				
Source	df	F-value	Prob. of Equality	R^2	CV	df	F-value	Prob. of Equality	R^2	CV	df	F-value	Prob. of Equality	R^2	CV
First Test:															
Bioassay Reps	5	11.42	<0.001	--	--	5	0.46	0.803	--	--	5	0.16	0.98	--	--
Concentration	6	63.10	<0.001	--	--	6	151.21	<0.001	--	--	6	151.05	<0.001	--	--
Exposure	3	54.21	<0.001	--	--	3	6.15	<0.001	--	--	3	7.17	<0.001	--	--
C vs. E Interact.	18	4.61	<0.001	--	--	18	1.21	0.26	--	--	18	1.51	0.095	--	--
Model	32	12.29	<0.001	0.84	27	32	30.06	<0.001	0.88	21	32	29.87	<0.001	0.88	23
Contrast:															
CK vs. All Treat	1	154.52	<0.001	--	--	1	10.22	0.002	--	--	--	--	115.02		
<0.001	--	--													
Second Test:															
Exposure Reps	2	2.29	0.114	--	--	2	2.67	0.082	--	--	2	0.44	0.648	--	--
Concentration	6	78.42	<0.001	--	--	6	110.85	<0.001	--	--	6	79.38	<0.001	--	--
Exposure	2	7.73	0.002	--	--	2	2.53	0.093	--	--	2	4.10	0.024	--	--
C vs. E Interact.	12	1.64	0.119	--	--	12	1.25	0.286	--	--	12	0.33	0.978	--	--
Model	22	23.19	<0.001	0.93	19	22	31.39	<0.001	0.95	14	22	22.24	<0.001	0.92	17
Contrast:															
CK vs. All Treat	1	15.46	<0.001	--	--	1	1.94	0.171	--	--	1	8.00	0.007	--	--

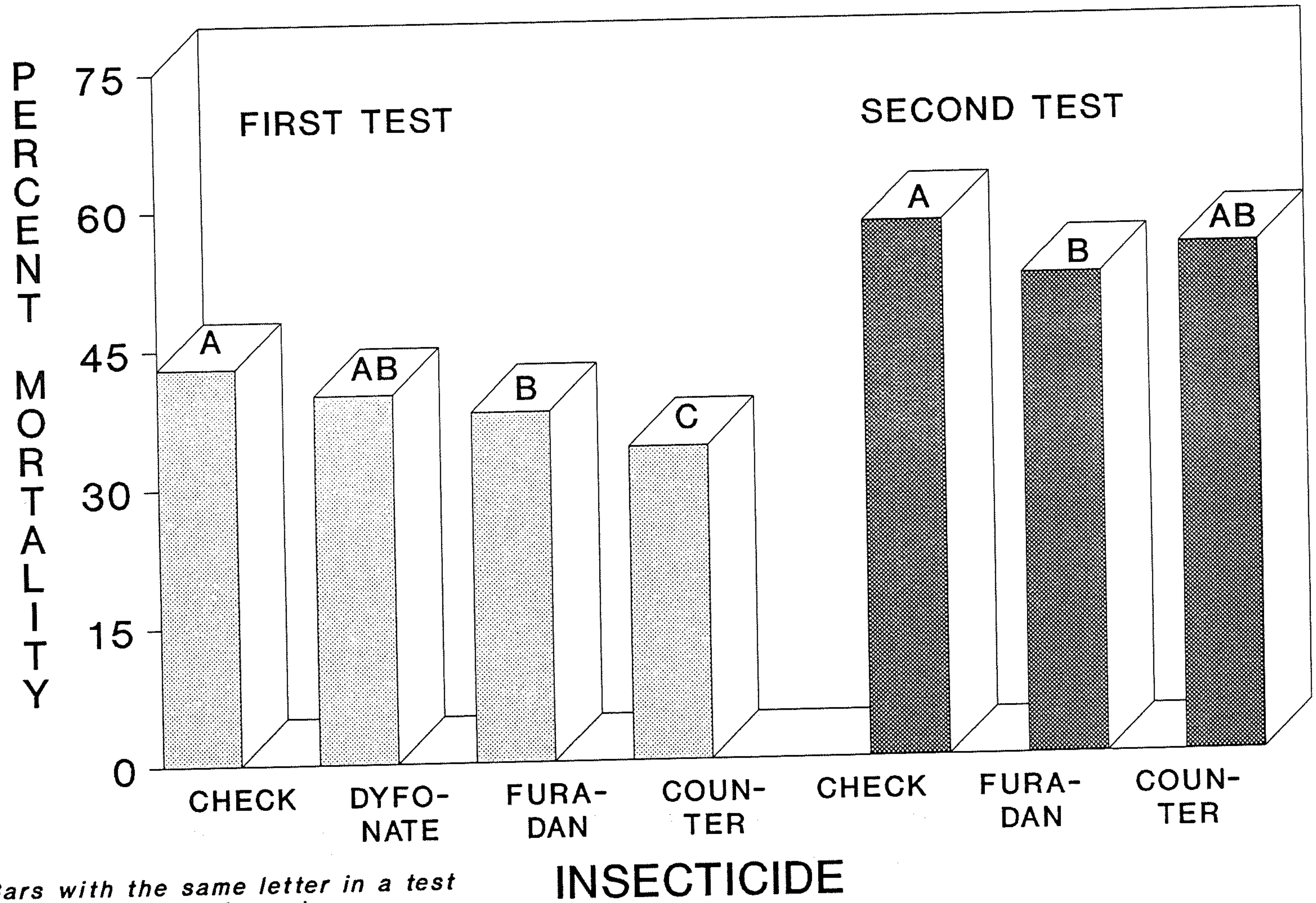
8-27

Fig. 1. Mortality to Cygon in Banks mites reared on untreated and soil insecticide treated corn plants.



* Bars with the same letter in a test are not different (P=.05).

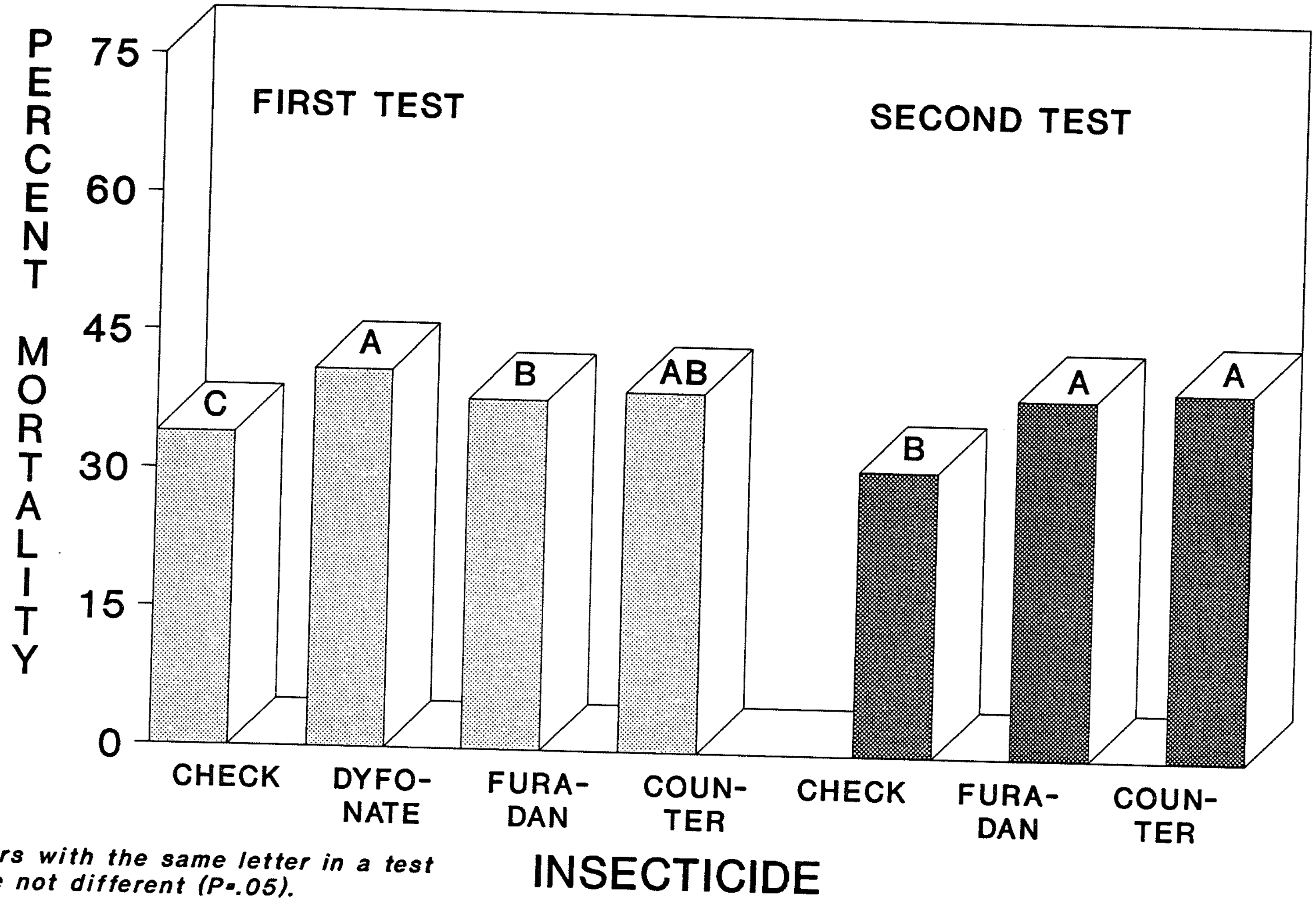
Fig. 2. Mortality to Supracide in Banks mites reared on untreated and soil insecticide treated corn plants.



* *Bars with the same letter in a test are not different (P=.05).*

8-29

Fig. 3. Mortality to Capture in Banks mites reared on untreated and soil insecticide treated corn plants.



* *Bars with the same letter in a test are not different (P=.05).*

SW Research-Extension Center
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EFFECTIVE PERSISTENCE IN CORN OF SEVEN PESTICIDES FOR BANKS GRASS MITE AND TWOSPOTTED SPIDER MITE

M.A. Chowdhury and L.L. Buschman

Summary

Effective persistence of seven pesticides in corn was estimated for Banks grass mite (BGM), and twospotted spider mite (TSM). Kelthane had the highest effective persistence for both TSM and BGM. Effective persistence of Capture was greater for TSM than BGM.

Introduction

The efficacy of an insecticide against a specific pest is generally expressed as percent control. This percent control is the end result of complex interactions involving the insecticide's intrinsic toxicity, selectivity, and residual action; density of the beneficial organisms; population dynamics of the pest; phenological stage of the crop; weather conditions, etc. Therefore, these results vary widely from test to test and year to year. Perhaps effective persistance would give a better understanding of the potential of the insecticide in a pest management situation. This information can be obtained by field-bioassaying the target pests at selected postapplication intervals. The results of these tests will not be affected as much by densities of beneficial insects or the population dynamics of the pest. The objective of this study was to estimate the effective persistence on corn of seven pesticides for Banks grass mite (BGM), *Oligonychus pratensis* (Banks), and twospotted spider mite (TSM), *Tetranychus urticae* Koch.

Procedures

This study was conducted in field corn in Finney Co., KS in 1987. The experiment was repeated three times. Seven pesticides were included: Cygon 400 (1.0 lb AI/A), Supracide 2E (0.5 lb AI/A), Capture 2E (0.08 lb AI/A), Furadan 4F (1.0 lb AI/A), Comite 6.55EC (1.67 lb AI/A), Metasystox-R 2SC (0.5 lb AI/A), and Kelthane[1] 1.6EC (1.0 lb AI/A). The first trial was conducted on early-whorl-stage corn, and the pesticides were applied on July 7 at 10 times the recommended field rate (listed above). Each treatment included 60 plants in a one-row plot. Coverage was increased by spraying both sides of the row with 2 liters of water (ca 2 minutes per plot). In the second and third trials, the pesticides were applied at recommended field rates on July 20 and October 7, respectively. Each treatment included 120 consecutive plants in a one-row plot. The second trial was done on mid-whorl-stage corn and the third trial on dent-stage corn.

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[1]Kelthane is a chlorinated hydrocarbon compound that is not labeled for corn, and the EPA has recently removed it from the market.

8-31

Bioassay: The persistence of the pesticides was estimated by placing individual, adult, female BGM or TSM confined in leaf-cages on treated leaf surfaces for 24 hours. The BGM and TSM were from laboratory colonies. Mites also were placed on untreated plants to serve as controls. The leaf-cages were made from double-adhesive, Scotch brand mounting squares (12.7 X 12.7 X 1.5 mm) with a 6.0 mm diameter opening, which served as the cage when covered with plastic film with fine mesh fabric. Eighteen cages were used in each bioassay for each chemical, three cages per plant. Nine cages were attached to the lower and nine to the upper leaf surfaces. The leaves with cages were brought to the laboratory to record mortality. Bioassays began 1 hour postapplication and were repeated at 1- or 2-day intervals until the mortalities dropped to <10%.

Analysis: Percent mortality on each sample date was corrected using Abbott's formula. Corrected mortalities were plotted against the post-application intervals (hours). Nonlinear regression analysis was used to derive the best fitting curve selected from the PLOTIT graphics and statistical software package. The total area below the fitted regression lines beginning from time-zero (Y-intercept) to 10% mortality was calculated. The total area under the fitted regression line is the sum of the products of Y-axis (% mortality) and X-axis (postapplication intervals in hours) and is expressed here as "mortality units". One mortality unit is equivalent to 1% death over 1 hour.

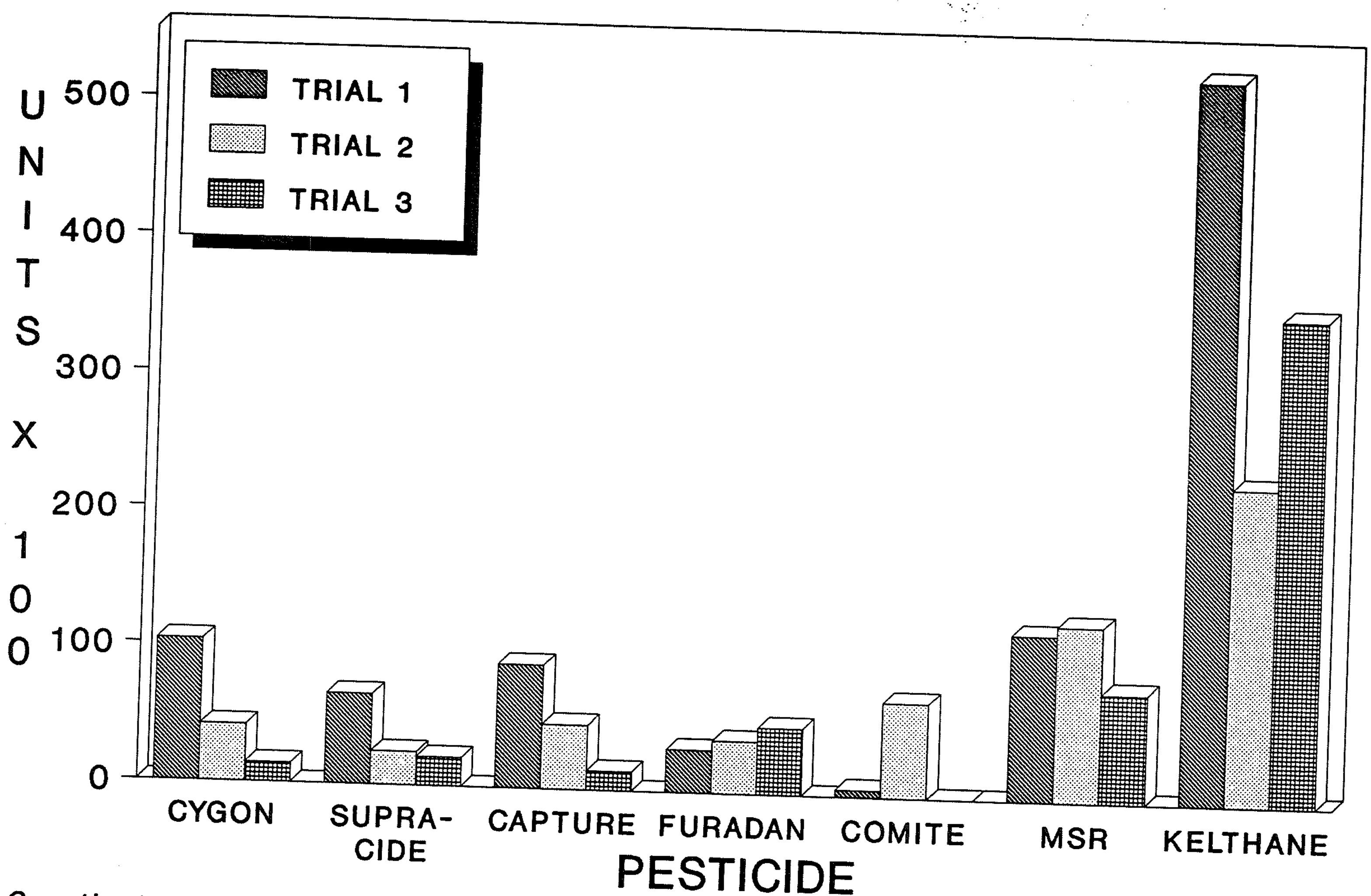
Results and Discussion

The effective persistence of pesticides against BGM was generally higher in the first trial, in which the pesticides were applied at 10 times the recommended field rate, than in the second and third trials (Fig. 1). Except for Furadan and Kelthane, effective persistence was relatively low in the third trial (on dent stage corn) compared to the second trial (on whorl stage corn). The low levels of effective persistence on dent-stage corn may be due to the retarded movement of pesticides in senescent leaves and/or reduced feeding by the mites on these leaves. The highest levels of effective persistence were observed for Kelthane in the first trial, in which it was nearly five times more effective than MSR, the second most effective chemical. The differences among other pesticides were not large.

Effective persistence of pesticides against TSM were generally low except for Kelthane (Fig. 2). The effective persistence was higher in second trial for all chemicals, except Kelthane. The highest levels of effective persistence were observed for Kelthane, and the second highest were for Capture. The performances of Comite, MSR, and Supracide were similar. In the first trial, the pesticides were applied at 10 times the recommended field rates, but the effective persistences (except for Kelthane) were low. Possibly at these high rates, the TSM were repelled from the leaf surface and they spent their time on the cages rather than on the leaf surface.

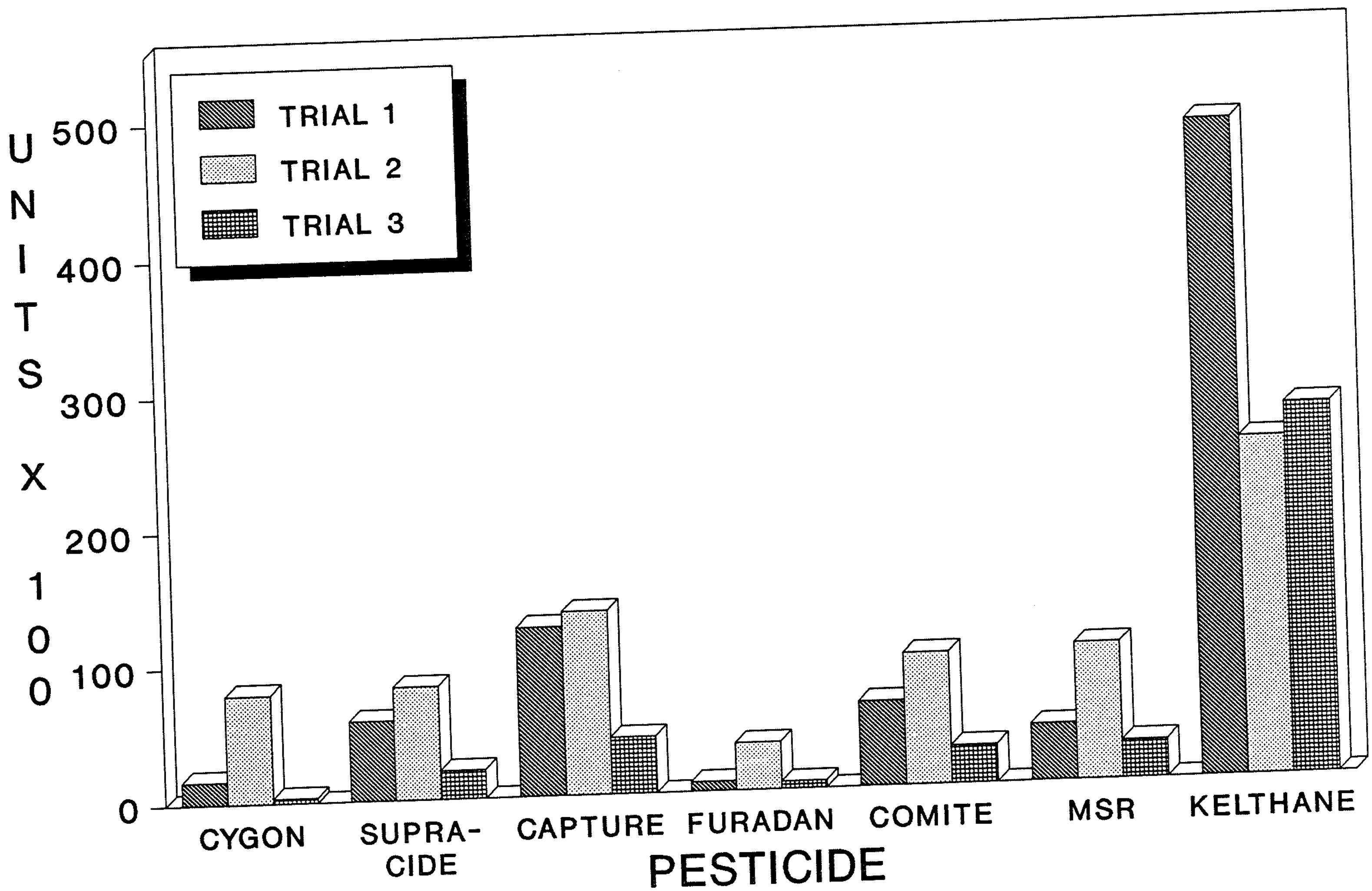
The relative impact of pesticides with a quick kill action versus a low but prolonged killing activity can be evaluated with these data. The overall killing power of a pesticide can be calculated irrespective of the differences in initial mortality. This point can be illustrated by examining the effective persistence of Cygon against BGM and TSM in the second trial (Figs. 1 & 2). The effective persistence of Cygon was about 2 times higher for TSM than BGM, in spite of the higher initial mortality of BGM (Fig. 3). Similar results were observed for Supracide, Capture, and MSR. Is it possible that some of these pesticides are actually suppressing the TSM more effectively than the BGM? Field experience would suggest otherwise.

Fig. 1. Calculated area under fitted regression lines. Banks Grass Mite.



Growth stages of corn used:
Trial 1 - Mid-Whorl, Trial 2 - Late-Whorl, Trial 3 - Dent

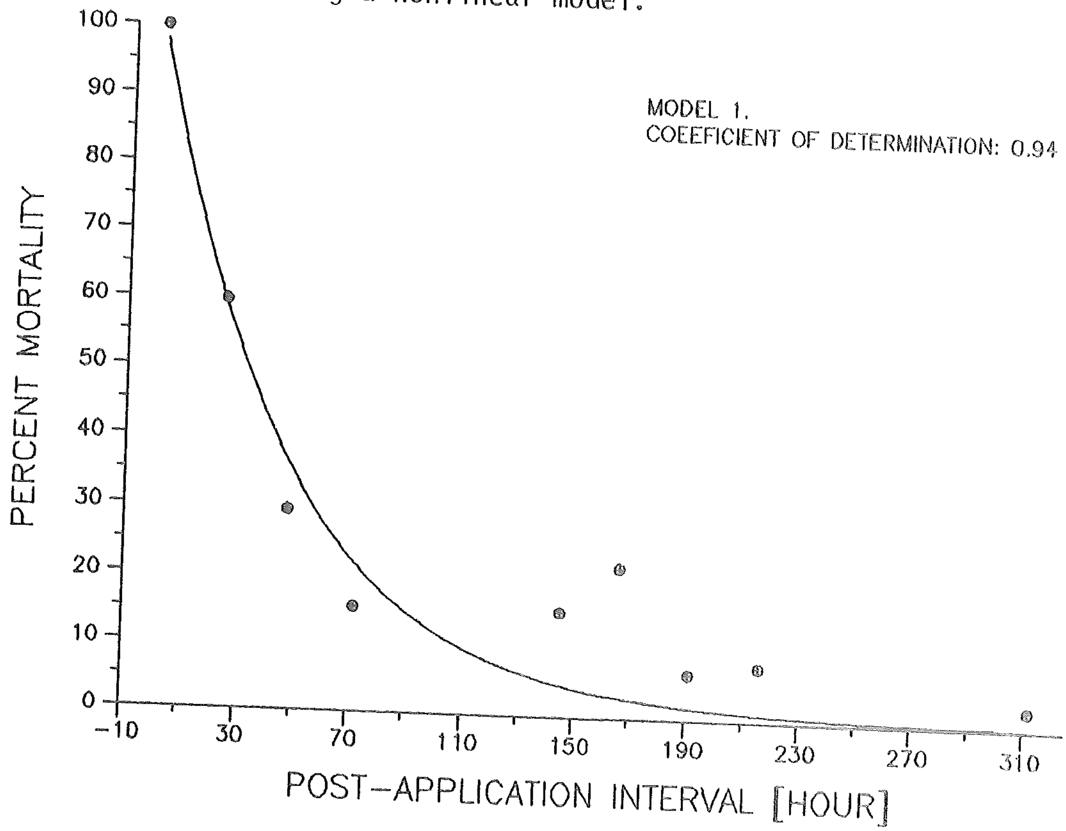
Fig. 2. Calculated area under fitted regression lines. Twospotted spider mite.



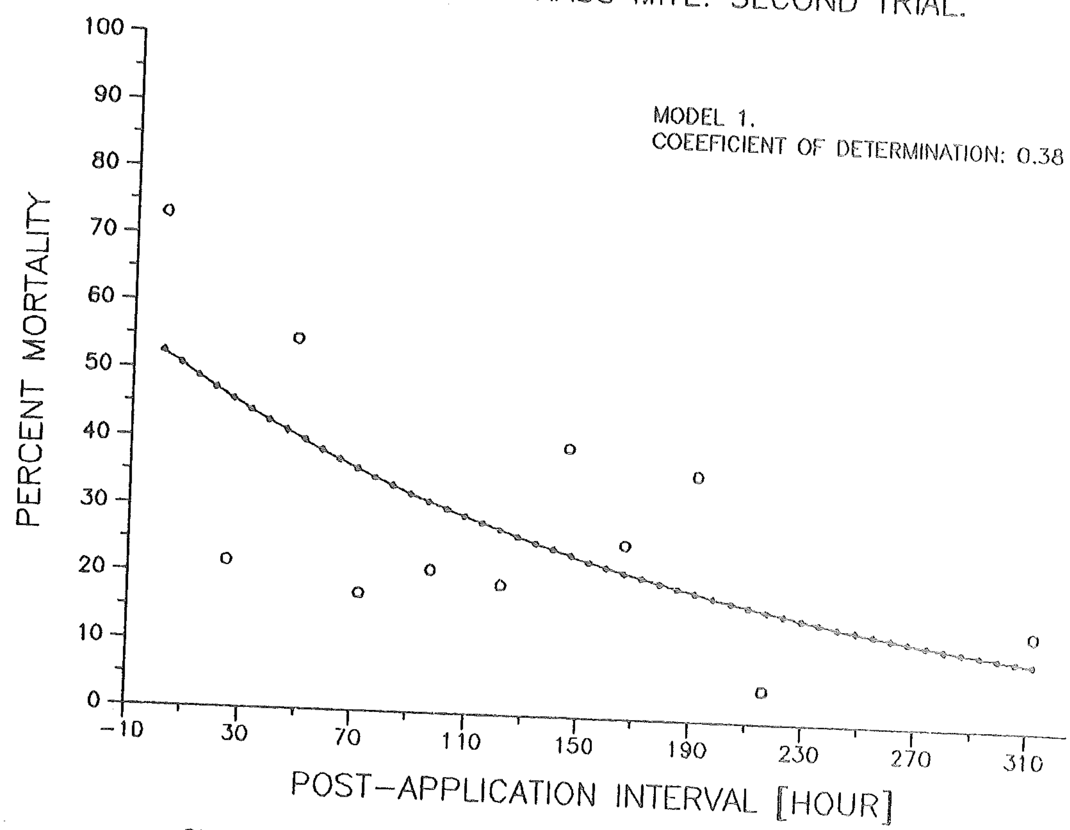
Growth stages of corn used:
Trial 1 - Mid-Whorl, Trial 2 - Late-Whorl, Trial 3 - Dent.

8-35

Fig. 3. Effective persistance of Cygon against Banks grass mite and twospotted spider mite. The best-fitting regression curve was drawn using a nonlinear model.



CYGON.BANKS GRASS MITE. SECOND TRIAL.



CYGON. TWOSPOTTED SPIDER MITE. SECOND TRIAL.

8-36

OVIPOSITION OF BANKS GRASS MITES AND TWOSPOTTED SPIDER MITES ON DIFFERENT GROWTH STAGES OF CORN AND SORGHUM

M. A. Chowdhury and L. L. Buschman

Summary

The oviposition of Banks grass mite (BGM) and twospotted spider mite (TSM) were studied on different growth stages of corn and sorghum. In corn, the BGM laid fewer eggs on dent-stage corn than on most other growth stages. In sorghum, they laid more eggs on younger growth stages, but the differences were not significant. In corn, the TSM laid significantly higher numbers of eggs on silking than on 9-leaf and dent-stage corn. In sorghum, they laid significantly higher numbers of eggs on 10-leaf than on the hard-dough growth stage

Introduction

Banks grass mite (BGM), *Oligonychus pratensis* (Banks), and twospotted spider mite (TSM), *Tetranychus urticae* L., populations are often associated with specific growth stages of the host plant. The rate of oviposition of BGM and TSM in sorghum and corn of different growth stages may provide information that will improve our understanding of spider mite population dynamics on these hosts. In this study, we examine the rates of oviposition of BGM and TSM on different growth stages of corn and sorghum under field conditions.

Procedures

Corn (Garst 8345) and sorghum (Garst 5715) were planted at 3-week intervals, so that a range of plant growth stages would be available at the same time. Individual, adult, female BGM or TSM were confined in leaf-cages and taken to the field and placed on each growth stage. The leaf-cages were made from double-adhesive, Scotch brand mounting squares (12.7 X 12.7 X 1.5 mm) with a 6.0 mm diameter opening that served as the cage when covered with plastic film with needle punctures for ventilation. In each growth stage of corn or sorghum, 25 cages with mites were placed on the lower surface of one mid-level leaf per plant. Oviposition observations were made at 2 or 4 days and again at 7 or 8 days posttreatment. The caged mites were brought back to the laboratory and examined under the microscope to count the eggs. After the first observation, the live mites were transferred to new cages and returned to the respective plots.

The BGM in this study were from a 2-year old colony maintained on whorl-stage corn. The TSM was field collected from soybean for two replicates and from corn for the other two replicates. The test with BGM was conducted 18 through 26 August and the test with TSM was conducted 31 August through 6 September, 1988.

8-37

Analysis: Oviposition data were standardized by transforming the counts as follows: No. eggs/mite/day = {[total no. eggs 1st observation / (no. live mites X hours confined)] + [total no. eggs 2nd observation / (No. live mites X hours confined)]} X 24 hours. The eggs in the cages with mites missing or dead were not included in these calculations. The BGM and TSM oviposition data were submitted to analysis of variance to determine statistical differences in oviposition of mites on different growth stages of corn and sorghum. The means were separated by using the Duncan's new multiple range test.

Results and Discussion

BGM on corn: Oviposition of BGM was significantly higher on blister than on dent-stage corn (Fig. 1). The oviposition on dent stage was significantly lower than oviposition on most other growth stages.

TSM on corn: Oviposition of TSM was significantly higher on silk-stage than on dent-or 9-leaf-stage corn (Fig. 2).

BGM on sorghum: Oviposition of BGM was slightly higher on the younger sorghum, but the differences were not statistically significant (Fig. 3).

TSM on sorghum: Oviposition of TSM was significantly higher on 10-leaf than on the hard-dough-stage sorghum (Fig. 4). The trend for decreasing oviposition on older stages of sorghum was more pronounced for TSM than for BGM.

Growth stages of corn and sorghum have important effects on the rates of oviposition by TSM and BGM. However, there is very little information on the underlying causes of these effects. Changes in the concentration of soluble sugars have been implicated by other workers. However, many other physiological changes also occur during plant development that have not been examined for effects on spider mites. The higher rates of BGM oviposition on younger corn are not in agreement with other observations in this laboratory.

8-38

Fig. 1. Oviposition of Banks grass mite on corn of five phenological stages.

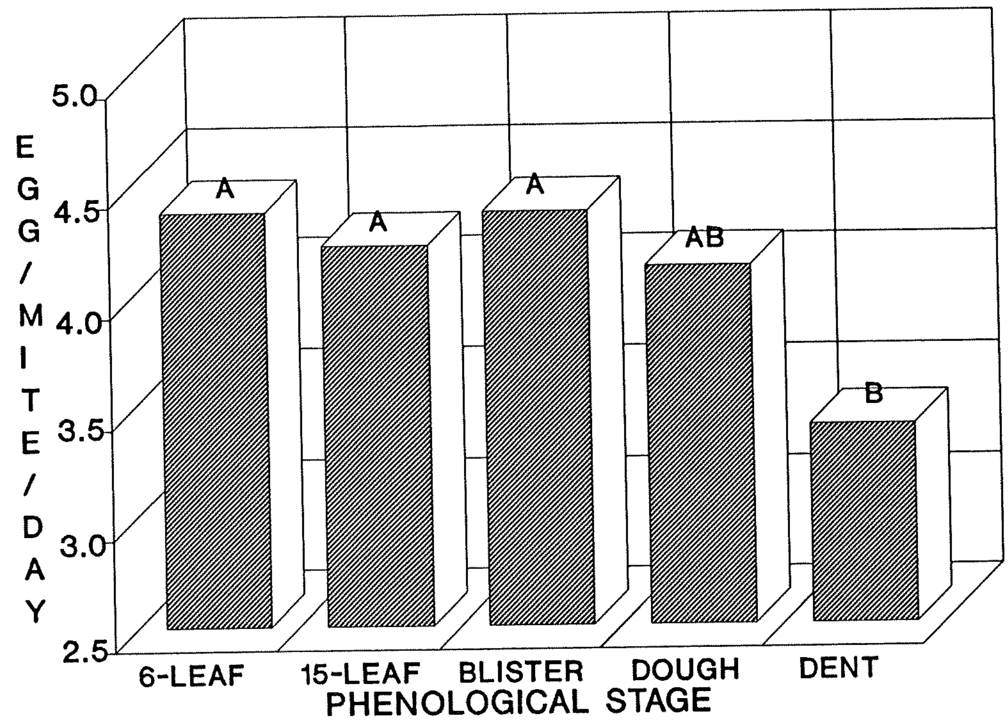
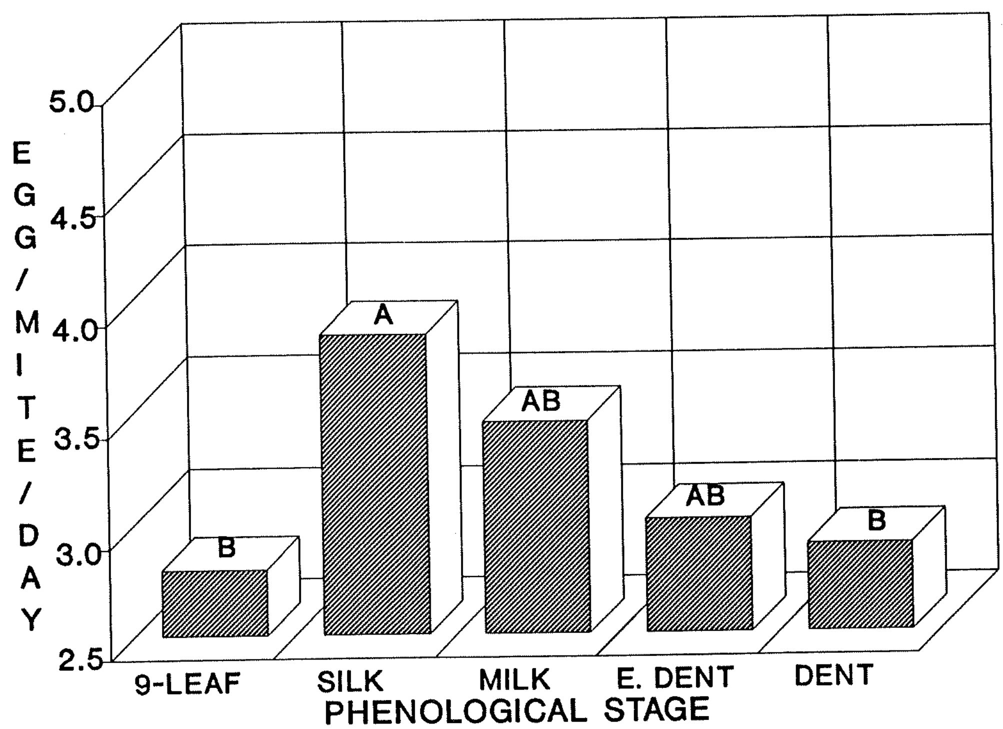


Fig. 2. Oviposition of Twospotted spider mite on corn of five phenological stages.



8-39

Fig. 3. Oviposition of Banks grass mite on sorghum of four phenological stages.

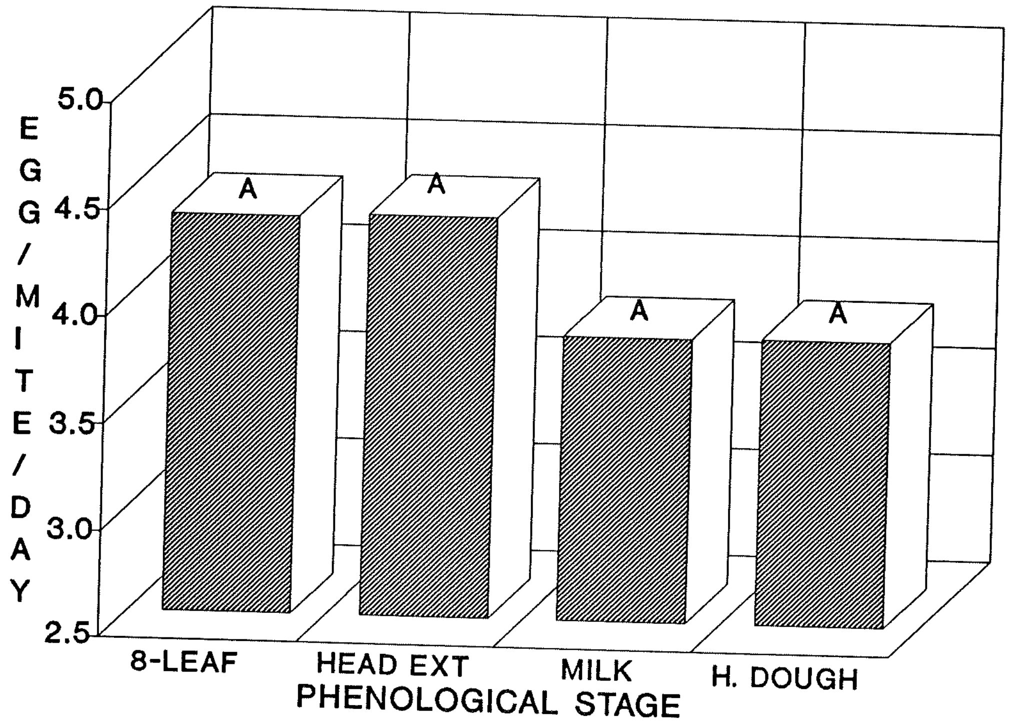
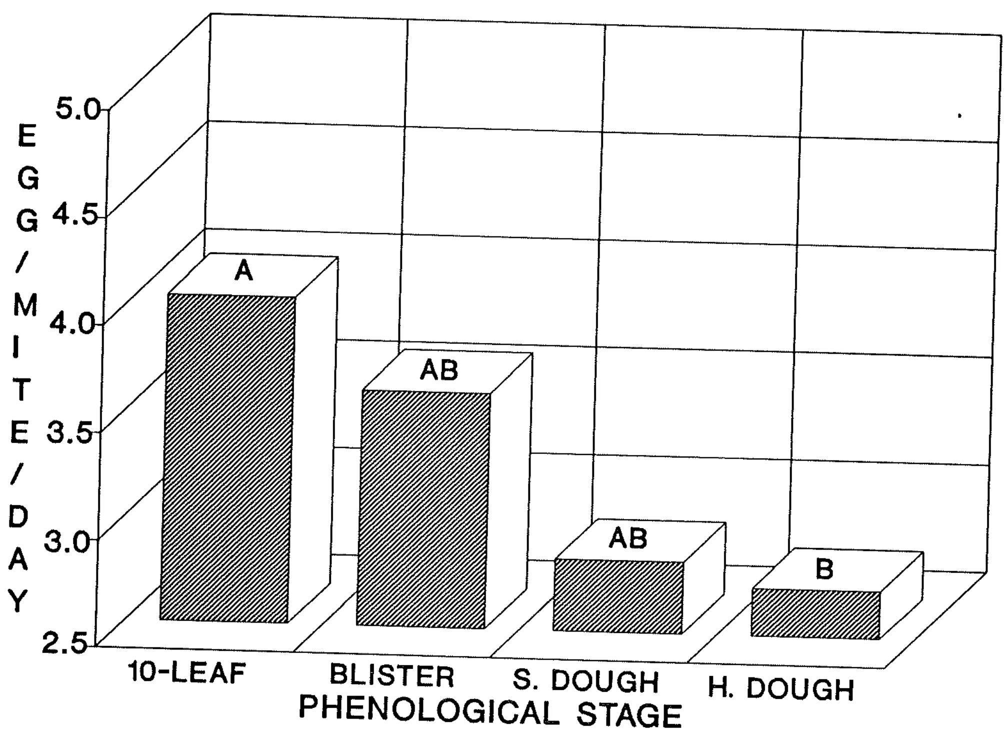


Fig. 4. Oviposition of Twospotted spider mite on sorghum of four phenological stages.



8-40

SW Research-Extension Center
Kansas State University

EFFICACY OF CAPTURE AGAINST SPIDER MITES AND SECOND GENERATION CORN BORERS, AERIAL TEST, 1988

L.L. Buschman

Summary

The pyrethroid miticide, Capture, was compared to Furadan plus Supracide for control of Banks grass mite and corn borers. Aerial sprays were applied to sprinkler-irrigated corn. Numbers of spider mites and corn borer larvae, as well as length and number of tunnels, were recorded. At 6 days posttreatment mite populations were reduced 88% by Capture, 45% by Capture plus oil, and 93% by Furadan plus Supracide. SWCB larvae were reduced 92 and 78 % by the Capture treatments, but not at all by the Furadan treatment. ECB larvae were reduced 88% by the Capture treatments and 48% by the Furadan treatment.

Introduction

This test was conducted to evaluate the efficacy of the new miticidal pyrethroid, Capture, for control of Banks grass mites (BGM), _Oligonychus pratensis_ (Banks), second generation European corn Borer (ECB), _Ostrinia nubilalis_ (Hubner), and southwestern corn borer (SWCB), _Diatraea grandiosella_ (Dyar).

Procedures

This experiment was conducted in sprinkler-irrigated corn in the sand hills of Finney County, Kansas. Treatments were applied with a Bull Thrush 1820 fixed wing plane (wing span = 45.5 ft), flying 130 mph, using Spraying Systems #3 hollow cone nozzles at 22 PSI, and delivering a volume of 2 GPA. Plots were three plane-swaths wide (except for one check plot that was two plane-swaths) (75-rows or 188 ft) and oriented east-west. The treatments were applied on the morning of 30 July when the temperature was 82^{o} F and the wind was 5 mph out of the west-southwest. Three treatments (Capture, Capture plus oil, and Furadan-Supracide) and a check were arranged in a randomized complete block design with three replications.

In each plot, five plants were flagged so that spider mites could be counted on the same plants at weekly intervals. The flagged plants were 150 ft into the field, starting 60 ft from the edge of the plot and then spaced 5 rows apart across the plot. Spider mites (mostly large adult females) were counted by searching leaves of each flagged plant. Counts were made on 28 July and 2, 5, 12 and 18 August. Before analysis, the spider mite counts were transformed using Taylor's power law (p = 0.23055). The data have been back-transformed for presentation.

Corn borer evaluations were made on 8 and 9 September by dissecting 25 plants in each plot (5 consecutive corn pants next to each flagged plant). The number of corn borer larvae (by species) and length and number of tunnels were recorded for each plant.

8-41

Results and Discussion

Pretreatment spider mite populations averaged 86 mites per plant. Spider mite damage was visible on some lower leaves. Spider mite populations were reduced by all three treatments from 3 days posttreatment to 20 days posttreatment, but the treatment effects were significant only on days 3 and 6 (Table 1). The use of EV-oil did not significantly improve Capture performance on BGM in these tests. Spider mite populations were 100 % BGM on 12 August (n = 111).

Corn borer pressure in untreated plots was heavy: SWCB averaged 2.5 larvae per plant with 93% of plants infested, and ECB averaged 1.4 larvae per plant with 60% plants infested. Both SWCB and ECB were significantly reduced by the two Capture treatments, but only ECB were reduced in the Furadan-Supracide treatment (Tables 2 and 3). Corn borer pressure was so heavy and prolonged that two applications of Furadan should have been made.

****
Acknowledgement:

The spider mite and corn borer data presented in this report are based on field counts made by the following summer assistants: Todd Staats, Shaun Moseman, Aaron Weaver, Marie Hamilton, Calana Needham, Alicia Molina, Mark Hannagan, Kathy Hernandez, and Steve Sandoval. Their conscientious efforts are gratefully acknowledged.
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Table 1. Effects of aerial applications of Capture and Furadan-Supracide on spider mite populations in field corn in southwest Kansas. Treatments were applied 30 July 1988.

Treatment, formulation, And rate (lb AI/A)	Mites per 5 plants-days posttreatment								
	-2 days	3 days	Percent control	6 days	Percent control	13 days	Percent control	20 days	Percent control
Untreated	636	187A	--	358A	--	289	--	1113	--
Capture[a] 2E 0.08	328	37AB	62	23 BC	88	49	67	435	2
Capture[a] 2E 0.08 + Oil[b]	339	12 B	88	106 B	45	230	-49	727	-22
Furadan 4F 1.0 + Supracide[a] 2E 0.5	415	8 B	93	16 C	93	66	65	290	60
ANOVA Table									
F-Value	1.87	3.19		11.17		1.23		1.55	
F-Test Prob.	0.235	0.105		0.007		0.378		0.311	
CV	9	34		18		32		19	

Treatment, formulation And rate (lb AI/A)	Mite Days per 5 plants	Percent control	Mite predators per 5 plants 28 July	Mite predators per 5 plants 18 August	Mite predators per 1000 mites 18 August
Untreated	14725A		0.7	23.3	50.2
Capture[a] 2E 0.08	3313 B	56	2.1	2.7	11.4
Capture[a] 2E 0.08 + Oil[b]	6428AB	18	5.4	15.0	27.3
Furadan 4F 1.0 +Supracide[a] 2E 0.5	2513 B	74	0.03	13.8	49.3
ANOVA Table					
F-Value	5.28		2.33	0.61	0.40
F-Test Prob.	0.052		0.174	<0.50	<0.50
CV	14		506	44	42

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).

[a] This product is not currently registered for use in corn.

[b] One pint emulsifiable, vegetable-based, crop oil.

Table 2. Effects of aerial applications of Capture and Furadan-Supracide on corn borer larvae in field corn in southwest Kansas. Treatments were applied 30 July 1988.

Treatment, formulation, And rate (lb AI/A)	4th & 5th instar larvae		All larvae		Infested plants	
	Number per 25 plants	Percent control	Number per 25 plants	Percent control	Number per 25 plants	Percent control
<u>Southwestern Corn Borer</u>:						
Untreated	42.7AB	--	61.7A	--	23.3A	--
Capture[a] 2E 0.08	3.3 B	92	5.3 B	91	4.0 C	83
Capture[a] 2E 0.08 + Oil[b]	9.3AB	78	11.7 B	81	8.3 B	64
Furadan 4F 1.0 + Supracide[a] 2E 0.5	53.3A	0	67.3A	0	22.0A	6
ANOVA Table						
F-Value	3.71		8.92		92.78	
F-Test Prob.	0.08		0.012		>0.001	
CV	81		52		12	
<u>European Corn Borer</u>:						
Untreated	29.3A	--	36.0A	--	15.0A	--
Capture[a] 2E 0.08	3.7 B	88	4.0 B	89	4.0 B	73
Capture[a] 2E 0.08 + Oil[b]	3.7 B	88	5.3 B	85	4.0 B	73
Furadan 4F 1.0 + Supracide[a] 8E 0.5	15.3 B	48	19.0AB	47	11.7A	22
ANOVA Table						
F-Value	10.03		8.01		11.23	
F-Test Probability	0.009		0.016		0.007	
CV	51		57		33	

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).

[a] This product is not currently registered for use in corn.

[b] One pint emulsifiable, vegetable-based, crop oil.

Table 3. Effects of aerial applications of Capture and Furadan-Supracide on corn borer tunneling and ear infestation in field corn in southwest Kansas. Treatments were applied 30 July 1988.

	Tunnels		Tunnel length below ear		Total tunnel length		Infested ears	
Treatment, formulation And rate (lb AI/A)	Number per 25 plants	Percent control	cm. per 25 plants	Percent control	cm. per 25 plants	Percent control	Number per 25 plants	Percent control
Untreated	96.7A	--	831A	--	987A	--	18.0A	--
Capture[a] 2E 0.08	13.7 B	86	60 B	93	77 B	92	5.3 B	71
Capture[a] 2E 0.08 + Oil[b]	21.3 B	78	155 B	81	186 B	81	5.7 B	68
Furadan 4F 1.0 + Supracide[a] 2E 0.5	103.3A	0	676AB	19	811AB	18	17.3A	4
ANOVA Table								
F-Value	11.91		4.27		4.80		8.82	
F-Test Prob.	0.006		0.061		0.049		0.012	
CV	41		74		69		35	

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).
[a] This product is not currently registered for use in corn.
[b] One pint emulsifiable, vegetable-based, crop oil.

SW Research-Extension Center
Kansas State University

EFFICACY OF DIPEL AGAINST SECOND GENERATION CORN BORERS AND EFFECTS ON SPIDER MITES, AERIAL TEST, 1988

L.L. Buschman

Summary

The biological insecticide, Dipel (with and without Comite), and a standard insecticide, Furadan (with Di-Syston), were tested for control of corn borers and Banks grass mites on corn. The treatments were applied twice in August. Numbers of spider mites, predators, and corn borer larvae and length of tunnels were recorded. Corn borer pressure was light, with 0.6 SWCB and 0.5 ECB per plant. Dipel treatments resulted in 21 and 42 % reduction of SWCB and 49 and 65% reduction of ECB. The Furadan treatment resulted in 92 and 100% reductions of SWCB and ECB, respectively. Spider mite populations declined in all plots so treatment differences were small. At 7 days posttreatment, spider mites were reduced 100% in the Dipel plus Comite treatment and 95% in the Furadan plus Di-Syston treatment but only 26% in the Dipel treatment.

Introduction

This test was conducted to evaluate the efficacy of the biological insecticide, Dipel, for control of second generation European corn Borer (ECB), *Ostrinia nubilalis* (Hubner), and second generation southwestern corn borer (SWCB), *Diatraea grandiosella* (Dyar), and for secondary effects on Banks grass mites (BGM), *Oligonychus pratensis* (Banks).

Procedures

This experiment was conducted in sprinkler-irrigated corn in Finney County, Kansas. Three treatments and a check were arranged in a randomized complete block design with three replications. Treatments were applied with a Air Tractor AT301, fixed-wing plane (wing span = 45.1 ft), flying 120 mph, using 30 Multi-Jet D3 or D12 hollow cone nozzles at 28 PSI, and delivering a volume of 3 GPA (Furadan-Di-Syston treatment)or 5 GPA (Dipel and Dipel-Comite Treatments). Plots were three plane-swaths wide (75 rows or 188 ft) and oriented north-south. The treatments were applied on the evening of 5 August, when the temperature was 75^{o} F and the wind was 8 mph out of the southeast. Repeat treatments (without miticides) were applied on the morning of 15 August, when the temperature was 82^{o} F and the wind was 6 mph out of the southeast.

Corn borer evaluations were made on 19 and 20 September by dissecting 25 plants in each plot (5 consecutive corn plants next to each flagged plant). The number of corn borer larvae (by species) and length and number of tunnels were recorded for each plant.

In each plot, five plants were flagged so that spider mites could be counted on the same plants. The flagged plants were 150 ft into the field,

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starting 60 ft from the edge of the plot and then spaced 5 rows apart across the plot. Spider mites (mostly large adult females) were counted by searching leaves of each flagged plant. Counts were made on 5, 12, and 28 August. Before analysis, the spider mite counts were transformed using Taylor's power law ($p = 0.23055$). The data have been back-transformed for presentation.

Results and Discussion

Corn borer pressure in untreated plots was light: SWCB averaged 0.6 larvae per plant with 52% of plants infested and ECB averaged 0.5 larvae per plant with 32% plants infested. The Dipel treatments resulted in 21 to 42 percent reduction of SWCB and 49 to 65 percent reduction of ECB, whereas the Furadan treatment resulted in 92 and 100 percent reductions of SWCB and ECB, respectively (Tables 1 and 2).

Pretreatment spider mite populations averaged 66 mites per plant. Spider mite damage on plants was not visible. Spider mite populations in both treated and untreated plots were substantially lower in posttreatment counts, than in pretreatment counts so the treatment differences were small (Table 2). This population decline may have been related to an area-wide natural decline in mite populations, perhaps caused by weather conditions or natural enemies. Spider mite populations were 100 % BGM on 12 September (n = 37).

Table 1. Effects of aerial applications of Dipel, Furadan, and miticides on corn borer larvae in field corn in southwest Kansas. Treatments were applied 5 and 15 August 1988.

Treatment, formulation, And rate (pt/A)	4th & 5th instar larvae		All larvae		Infested plant	
	Number per 25 plants	Percent control	Number per 25 plants	Percent control	Number per 25 plants	Percent control
<u>Southwestern Corn Borer</u>:						
Untreated	15.7A	--	16.0A	--	13.0A	--
Dipel ES 2	8.3 B	47	9.3 B	42	8.3A	36
Dipel ES 2 + Comite 6.55EC 2	11.0AB	30	12.7AB	21	11.0A	15
Furadan 4F 1.5 + Di-Syston 8EC 0.5	1.3 C	92	1.3 C	92	1.3 B	90
ANOVA Table						
F Value	13.50		15.87		12.92	
F Test Probability	0.009		0.002		0.004	
CV	31		28		29	
<u>European Corn Borer</u>:						
Untreated	11.3A	--	12.3A	--	8.0A	--
Dipel ES 2	4.3 B	62	6.3 B	49	5.3AB	34
Dipel ES 2 + Comite 6.55E 2	2.7 BC	76	4.3 BC	65	3.0 BC	63
Furadan 4F 1.5 + Di-Syston 8EC 0.5	0.0 C	100	0.0 C	100	0.0 C	100
ANOVA Table						
F Value	25.06		11.81		10.69	
F Test Probability	>0.001		0.006		0.008	
CV	37		45		44	

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).

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Table 2. Effects of aerial applications of Dipel, Furadan, and miticides on corn borer tunneling and ear infestation and on spider mite and spider mite predator populations in field corn in southwest Kansas. Treatments were applied 5 and 15 August 1988.

Treatment, formulation, And rate (pt/A)	Tunnel number per 25 plants	Tunnel number Percent control	Tunneling below ear Cm per 25 plants	Tunneling below ear Percent control	Total tunneling Cm per 25 plants	Total tunneling Percent control	Infested ears Number Per 25 plants	Infested ears Percent control
Untreated	9.0 B	--	286A	--	320A	--	39.4A	--
Dipel ES 2	12.3 B	-37	184 B	36	187 B	42	0.0 B	100
Dipel ES 2 + Comite 6.55EC 2	12.7 B	-41	198 B	31	200 B	38	0.2 B	99
Furadan 4F 1.5 + Di-Syston 8EC 0.5	23.3A	-159	22 C	92	22 C	93	0.0 B	100
ANOVA Table								
F Value	21.24		79.04		95.78		5.70	
F Test Probability	0.001		<0.001		<0.001		0.034	
CV	16		12		12		107	

Treatment, Formulation And Rate (pt/A)	Mites per 5 plants 25 July	12 Aug	Percent Control	28 Aug	Percent Control	Mite Days per 5 plants	Mite Days Percent Control	Predators per 5 plants pretreat.	posttreat.
Untreated	313	15A	--	11AB	--	4088	--	0.67	11.3
Dipel ES 2	226	8AB	26	6B	25	2897	2	2.77	16.8
Dipel ES 2 +Comite 6.55EC 2	324	0 C	100	8AB	30	4000	5	4.82	3.1
Furadan 4F 1.5 +Di-Syston 8EC 0.5	454	1 B	95	26A	-63	5851	1	2.30	4.5
ANOVA Table									
F-Value	1.75	12.95		3.22		1.70		0.81	2.30
F-Test Probability	0.255	0.004		0.103		0.266		<0.50	0.177
CV	9	25		15		9		35	21

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).

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EFFICACY OF AERIAL APPLICATIONS OF SAVEY FOR SEASON-LONG SPIDER MITE CONTROL IN CORN, 1988

L.L. Buschman

Summary

The experimental long-residual miticide, Savey, and the standard miticide, Comite, were tested for control of Banks grass mites on corn. Aerial sprays were applied to three plantings of furrow-irrigated corn. Corn borer treatments, which sometimes cause spider mite outbreaks, were superimposed on the miticide treatments with ground equipment. Numbers of spider mites and mite predators were recorded. Spider mite populations remained low, even after the corn borer treatments were applied. Percent control of mites was positive in four of the six planting date/sample date combinations of Savey and two of the six combinations of Comite. Percent mite control was positive for Furadan but was negative for Pydrin and Dipel. Mite predator numbers did not appear to be affected by the treatments.

Introduction

The following study was conducted to test the effectiveness of the new long-residual miticide, Savey, and a standard long-residual miticide, Comite, on corn for controlling Banks grass mites (BGM), Oligonychus pratensis (Banks). The miticides were applied to corn at three growth stages to determine the best application time to prevent spider mite population build-up. These miticides have prolonged residual activity, but are relatively safe for the beneficial arthropods and, thus, are less likely to cause secondary pest outbreaks. Corn borer treatments, which sometimes cause spider mite outbreaks, were superimposed on the miticide treatments in one planting of corn, so that the miticides could be evaluated under different pressures from spider mites.

Procedures

This experiment was conducted in furrow-irrigated field corn at the Southwest Kansas Research-Extension Center in Finney County, Kansas. Corn was planted on three dates in a 920 ft-long field: 36 rows were planted (north-south orientation) on the first planting date (2 May) and eight rows were planted on both the second (23 May) and third (13 June) planting dates. The field was divided into 12 75-ft long sections, but only the middle 50 ft of each section was utilized as plot area. Aerial miticide treatments, Savey (1.5 oz AI/A) or Comite 1.67 lb AI/A), and a check were made across the rows (east-west orientation) in a randomized complete block design with four replications. The treatments were applied with a Bull Thrush 1820 fixed-wing plane (wing span = 45.5 ft, swath width = 66 ft) flying 130 mph, using Spraying Systems # 3 hollow cone nozzles at 22 PSI, and delivering a volume of 2 GPA. The treatments were applied on the morning of 14 July, when the temperature was 78^{0} F and the wind was 8 mph from the south-southwest.

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Corn borer treatments, Furadan (1 bl/A), Pydrin (0.15 lb/A), and Dipel (2 pt/A), and a check were superimposed on the miticide treatments for the first planting date. The 36 rows of corn were divided into alternating four-row borders and four-row plots (10 ft). These treatments were applied with a high clearance sprayer using a 10 ft boom with three nozzles directed at each row (one nozzle directly over the row and one on each side of the row on 18-inch drop hoses). The sprayer was calibrated to deliver 40 GPA at 30 PSI of CO_2 pressure. These treatments were applied on 4 August.

Prior to the first treatment, four plants in the center two rows of each four-row plot were flagged. Mite populations on these plants were augmented by attaching BGM-infested leaves on 5 and 11 July. Mite counts were made by searching all leaves of flagged plants for large mites (primarily adult females). Pretreatment counts were made on 7 July. Posttreatment counts were made on 27 July and 8 August. Mite counts were calculated as mites per four plants and transformed using Taylor's power law (p = 0.23055) for statistical analysis. Accumulated mite-days were calculated for each plot by multiplying the number of mites for each sample date by the interval (number of days) they represented: from inoculation to the miticide treatments (14 days), from the miticide treatments to the corn borer treatments (20 days), or from the corn borer treatments to the final counts (5 days). For analysis, the data was divided into two sections: the miticide-by-planting date experiment (all plots untreated for corn borers) and the miticide-by-corn borer treatment experiment (all plots at the first planting date). At the end of the season, mites were collected from the flagged plants with a small vacuum sampler and mounted for microscopic determination of species.

Results and Discussion

Early-season mite populations were high, but late-season populations did not develop, even after the corn borer treatments were applied. The spider mite populations were 100% BGM (n = 52) on 8 August.

In the miticide-by-planting date experiment, the main effects of planting date and miticide treatment on spider mite (Table 1) and mite predator (Table 2) populations were not statistically significant (p=0.05). However, the percent control values (calculated using the Henderson and Tilton formula, which takes into consideration the pretreatment counts) give some interesting trends. The percent control was positive in four of the six and two of the six planting date/sample date combinations for Savey and Comite, respectively (Table 1). Mite predator numbers did not appear to be affected by the treatments (Table 2).

In the miticide-by-corn borer treatment experiment, the main effects of corn borer treatment on spider mite populations (Table 3) was significant (p=0.05). The percent control for Furadan was positive (52%), but it was negative for Pydrin (-18) and Dipel (-35%). The main effect of miticide treatment on spider mite populations (Table 3) was not significant (p=0.05). The percent control was positive for both Savey (23 and 67%) and Comite (31 and 56%). Mite predator numbers did not appear to be affected by the treatments (Table 4).

Table 1. Effects of Savey and Comite on Banks grass mite populations, 1988. The miticides were applied on 14 July when the corn was in the following growth stages: planting #1, 18-leaf; planting #2, 12-leaf; and planting #3, 7-leaf.

Treatment, formulation, and rate (lb AI/A)	Mites per 4 plants					Mite days	
	7 July	27 July	Percent control[a]	8 Aug	Percent control[a]	per 4 plants	Percent control[a]
Planting 1							
Check	76.8	13.8	--	1.50	--	820	--
Savey[b] 23%F 0.09	91.0	26.8	-64	1.00	44	1177	-21
Comite 6.55E 1.67	71.0	27.8	-118	3.75	-170	1071	-41
Planting 2							
Check	87.3	41.8	--	4.25	--	1467	--
Savey[b] 23%F 0.09	84.5	52.5	-30	0.00	100	1641	-16
Comite 6.55E 1.67	61.0	37.8	-29	1.50	50	1190	-16
Planting 3							
Check	71.3	24.5	--	0.25	--	990	--
Savey[b] 23%F 0.09	70.5	16.8	31	0.00	100	829	15
Comite 6.55E 1.67	90.3	23.8	23	2.00	-532	1117	11
ANOVA-Table							
Planting Date							
F-Value	0.02	2.33		0.87		1.70	
F-Test Prob	>0.50	0.12		>0.50		0.20	
Miticide Treatments							
F-Value	0.43	0.09		2.60		0.08	
F-Test Prob.	>0.50	>0.50		0.09		>0.50	
Interaction							
F-Value	1.42	0.49		0.76		0.53	
F-Test Prob	0.26	>0.50		>0.50		>0.50	
Experiment CV%	7	18		130		12	

a Percent control calculated using the Henderson and Tilton formula.
b This product is not currently registered for use in corn.

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Table 2. Effects of Savey and Comite on mite predator populations, 1988. The miticides were applied on 14 July when the corn was in the following growth stages: planting #1, 18-leaf; planting #2, 12-leaf; and planting #3, 7-leaf.

Treatment, formulation, and rate (lb AI/A)	Predators 7 July		Predators 27 July		Predators 8 Aug
	per 4 plants	per 1000 mites	per 4 plants	per 1000 mites	per 4 plants
Planting 1					
Check	3.25	43	4.25	268	0.25
Savey[a] 23%F 0.09	3.75	52	2.00	84	0.75
Comite 6.55E 1.67	1.50	28	0.50	11	0.50
Planting 2					
Check	1.50	18	1.754	106	0.75
Savey[a] 23%F 0.09	2.00	24	2.50	103	1.25
Comite 6.55E 1.67	4.00	66	0.50	23	1.75
Planting 3					
Check	3.00	46	1.50	125	1.00
Savey[a] 23%F 0.09	4.25	77	0.75	37	0.25
Comite 6.55E 1.67	2.25	31	0.75	76	1.50
ANOVA-Table					
Planting Date					
F-Value	0.42	0.61	0.87	0.33	1.57
F-Test Prob	>0.50	>0.50	>0.50	>0.50	0.23
Miticide Treatments					
F-Value	0.71	0.61	2.06	2.41	1.11
F-Test Prob.	>0.50	>0.50	0.15	0.11	0.35
Interaction					
F-Value	2.28	2.14	0.73	0.76	0.76
F-Test Prob	0.09	0.11	>0.50	>0.50	>0.50
Experiment CV%	63	79	145	161	117

[a]This product is not currently registered for use in corn.

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Table 3. Effects of corn borer insecticides and long-residual miticides on Banks grass mite populations, 1988. The miticides were applied on 14 July when the corn was in the 18-leaf stage. The corn borer insecticides were applied on 4 August when the corn was in the blister stage.

Treatment, formulation, and rate (lb AI/A)	Mites per 4 plants					Mite days	
	7 July	27 July	Percent control[a]	8 Aug	Percent control[a]	per 4 plants	Percent control[a]
Corn Borer Treatments							
Means							
Untreated	79.6	22.8	--	2.08	--	1023	--
Furadan 4F 1.0	85.1	19.0	--	0.83	52	980	-287
Pydrin 2.4E 0.15	76.8	25.5	--	2.75	-18	1061	-212
Dipel ES 2pt	74.3	29.1	--	3.58	-35	1119	-189
F-Value	0.74	1.01		3.30		0.39	
F-Test Probability	>0.50	0.40		0.032		>0.50	
Miticide Treatments							
Means							
Untreated	75.4	28.3	--	3.81	--	1112	--
Savey[b] 23%F 0.09	82.4	23.7	23	1.38	67	1058	13
Comite 6.55E 1.67	78.9	20.3	31	1.75	56	968	17
F-Value	0.65	2.21		1.00		1.27	
F-Test Probability	>0.50	0.13		>0.50		0.29	
Interactions							
F-Value	0.99	2.30		1.16		1.47	
F-Test Probability	>0.50	0.057		0.35		0.22	
Experiment CV%	5	12		110		6	

[a] Percent control calculated using the Henderson and Tilton formula.
[b] This product is not currently registered for use in corn.

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Table 4. Effcts of corn borer insecticides and long-residual miticides on mite predator populations. The miticides were applied on 14 July when the corn was in the 18-leaf setage. The corn borer insecticides were applied on 4 August when the corn was in the blister stage.

Treatment, formulation, and rate (lb AI/A)	Predators 7 July		Predators 27 July		Predators 8 Aug
	per 4 plants	per 1000 mites	per 4 plants	per 1000 mites	per 4 plants
Corn Borer Treatments					
Means					
Untreated	2.83	41	2.25	121	0.50
Furadan 4F 1.0	3.42	42	2.58	202	0.42
Pydrin 2.4E 0.15	3.00	42	2.25	204	0.58
Dipel ES 2pt	2.67	36	0.75	45	1.08
F-Value	0.21	0.09	1.58	1.97	1.87
F-Test Probability	>0.50	>0.50	0.21	0.14	0.15
Miticide Treatments					
Means					
Untreated	3.81	53	2.31	122	0.75
Savey[a] 23%F 0.09	2.88	37	2.25	173	0.75
Comite 6.55E 1.67	2.25	31	1.31	134	0.44
F-Value	1.63	1.43	0.98	0.33	0.90
F-Test Probability	0.21	0.25	>0.50	>0.50	>0.50
Interactions					
F-Value	0.76	0.62	0.93	1.53	1.87
F-Test Probability	>0.50	>0.50	>0.50	0.20	0.11
Experiment CV%	83	92	115	131	118

[a]This product is not currently registered for use in corn.

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SW Research-Extension Center
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EFFICACY OF LONG-RESIDUAL MITICIDES FOR SEASON-LONG SPIDER MITE CONTROL IN CORN, 1988

L.L. Buschman and P.E. Sloderbeck

Summary

Six long-residual miticides were tested for control of Banks grass mites in corn. Plants were sprayed at mid-whorl, late-whorl, and blister growth stages. Numbers of mites and mite predators were recorded. Spider mite populations did not increase during the season, so differences between treatments were small. Only Savey had consistent positive percent control of spider mites at each plant growth stage. Comite had positive percent control of mites at the late-whorl stage, but control was questionable at the other stages. Apollo, Mitac, and Kelthane had mostly positive percent control of mites at the mid-whorl stage, but not at the late-whorl stage.

Introduction

The following study was conducted to test the effectiveness of long-residual miticides applied to corn at several growth stages to control Banks grass mites (BGM), *Oligonychus pratensis* (Banks), and twospotted spider mites (TSM), *Tetranychus urticae* Koch. The miticides used in this study are thought to be relatively safe for beneficial arthropods and, thus, are less likely to cause secondary pest outbreaks.

Procedures

This experiment was conducted in two furrow-irrigated corn fields at the Southwest Kansas Research-Extension Center in Finney County, Kansas. Treatments were arranged in a randomized complete block design with four replications in each field. The plots were four rows wide (10 ft), 45 ft long, and surrounded by 10 ft borders of untreated corn. Chemical treatments were applied with a high clearance sprayer using a 10 ft boom with three nozzles directed at each row (one nozzle directly over the row and one on each side of the row on 18-inch drop hoses). The sprayer was calibrated to deliver 40 GPA at 30 PSI of CO_2 pressure. The experiment consisted of two trials. In the first trial, plots received single treatments during either the mid-whorl (8th leaf collar visible, 18 June), or the late-whorl (14th leaf-collar visible, 30 June) growth stages. In the second trial, single treatments were made during the blister growth stage (3 August). The corn in the first trial was oversprayed on 2 August with Pydrin (0.15 lb AI/acre) to control corn borers and to encourage spider mite population buildup.

Prior to the first treatments, four plants in the center two rows of each plot were flagged. Mite populations on these plants were augmented by attaching BGM-infested leaves on 10 June. Mites (primarily adult females) and mite predators (predator mites, *Orius* nymphs, thrips etc.) were counted in the field by searching the leaves of flagged plants. In the first trial pretreatment counts were made on 16 June and posttreatment counts on 28 June,

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21 July, and 10 August. In the second trial, pretreatment counts were made on 27 June and posttreatment counts on 11 August. Mite counts were converted to mites per four plants and transformed using Taylor's power law (p = 0.23055) for statistical analysis. Accumulated mite-days were calculated for each plot by multiplying the number of mites for each sample date by the respective intervals (days): from inoculation to the first treatment (8 days), from the first treatment to the second treatment (12 days), from the second treatment to the corn borer treatment (28 days), and from the corn borer treatment to 6 days past the fourth count (14 days). At the end of the season, a random sample of mites were collected from the flagged plants with a small vacuum sampler and mounted for microscopic determination of species.

Results and Discussion

Early-season mite populations were high, but late-season populations did not develop, even after the corn borer treatments were applied. In the first trial, the spider mite populations were 98% BGM (n = 228) on 10 August. In the second trial, the spider mite populations were 100% BGM (n = 323) on 11 August.

The differences among treatments were statistically significant (p = 0.05) only in the first trial (Table 1) for mites counts on 28 June and for the accumulated mite days, but these responses to miticide treatments are difficult to interpret. However, the percent control values (calculated using the Henderson and Tilton formula, which takes into consideration the pretreatment counts) show some interesting trends. Only Savey had consistent positive percent control of spider mites (9 of 9 treatment-sample combinations in the three treatment times) (Tables 1 and 3). Comite had positive percent control of spider mites at the late-whorl stage, but had questionable control at the other two stages (Tables 1 and 3). Apollo, Mitac, and Kelthane had mostly positive percent control of spider mites at the mid-whorl stage, but mostly negative control at the late-whorl stage (Table 1). A1335 may have useful activity against BGM, because it had mostly positive percent control of spider mites (13 of 16 treatment-sample combinations) across the three treatment timings and the two treatment rates (Table 1 and 3). Mite predator numbers did not appear to be affected by the treatments (Tables 2 and 3).

Table 1. Efficacy of long-residual miticides applied to corn at two growth stages corn for spider mite control, Southwest Kansas Research-Extension Center. The mid-whorl stage treatments were applied on 18 June and the late-whorl stage treatments were applied on 30 June 1988.

Treatment, formulation, and rate (lb AI/A)	Mites per 4 plants: 16 June	28 June	Percent control[a]	21 July	Percent control[a]	10 Aug.	Percent control[a]	Mite Days: per 4 plants	Percent control[a]
Check Plots:									
Untreated	28.3	26.0 ABCD		8.0		5.8		842 BCD	
Mid-whorl Stage Treatments:									
A1335[b] Liq.25 0.125	34.0	22.3 ABCD	29	4.8	50	21.0	-201	966 ABCD	3
A1335[b] Liq.25 0.185	29.0	10.3 DE	61	3.5	57	2.8	53	492 D	43
Comite 6.55EC 1.67	33.5	38.5 ABC	-25	9.3	2	16.5	-140	1220 ABC	-22
Savey[b] 23%F 0.09	42.5	13.0 CDE	67	6.3	48	7.3	16	773 BCD	39
Apollo[b] 50SC 1.5	29.8	18.0 ABCDE	34	2.8	67	5.8	5	612 CD	31
Mitac[b] 1.5EC 1.0	27.3	30.5 ABCD	-22	3.3	57	3.3	41	721 BCD	11
Kelthane[b] 1.6EC 1.0	37.8	5.3 E	85	9.3	13	6.5	16	715 BCD	36
Late-whorl Stage Treatments:									
A1335[b] Liq.25 0.125	23.5	30.5 ABCD	--	2.5	73	5.8	15	705 BCD	29
A1335[b] Liq.25 0.185	26.5	29.3 ABCD	--	15.3	-70	3.5	46	1039 BCD	-10
Comite 6.55EC 1.67	22.0	52.8 AB	--	9.0	45	2.3	81	1096 ABCD	36
Savey[b] 23%F 0.09	37.8	38.5 ABC	--	3.3	72	4.0	53	911 BCD	27
Apollo[b] 50SC 0.5	29.5	13.8 CDE	--	1.5	65	5.5	-79	520 D	-16
Mitac[b] 1.5EC 0.5	27.8	25.5 ABCD	--	45.8	-484	9.0	-58	1935 A	-134
Mitac[b] 1.5EC 0.75	24.5	31.5 ABCD	--	27.0	-179	19.0	-170	1596 ABC	-57
Mitac[b] 1.5EC 1.0	32.5	28.0 ABCD	--	17.5	-103	23.3	-273	1412 AB	-56
Kelthane[b] 1.6EC 1.0	27.5	61.3 A	--	19.0	-1	18.0	-31	1739 ABC	12
Avid[b] 0.15EC 0.02	38.3	20.8 BCDE	--	4.8	25	2.8	40	727 BCD	-8
ANOVA Table									
F-Value	1.49	2.49		1.26		0.72		2.31	
F-Test Probability	0.14	0.006		0.26		>0.50		0.011	
Experiment CV	7	17		54		53		11	

Means in the same column followed by the same letter are not significantly different (P = 0.05) DMRT.

[a] Percent control calculated using the Henderson and Tilton formula.

[b] This product is not currently registered for use in corn.

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Table 2. Effects of long-residual miticides applied to corn at two growth stages on mite predators, Southwest Kansas Research-Extension Center. The mid-whorl stage treatments were applied on 18 June and the late-whorl stage treatments were applied on 30 June 1988.

Treatment, formulation, and rate (lb AI/A)	16 June Predators per		28 June Predators per		21 July Predators per	
	4 plants	1000 mites	4 plants	1000 mites	4 plants	1000 mites
Check Plots						
Untreated	1.0	41.4	8.5	2830	0.5 C	45
Mid-whorl Stage Treatments:						
A1335[a] Liq.25 0.125	1.5	40.2	4.3	218	3.3 ABC	417
A1335[a] Liq.25 0.185	1.3	41.5	5.5	494	1.3 BC	333
Comite 6.55EC 1.67	2.0	53.9	9.5	366	4.3 AB	619
Savey[a] 23%F 0.09	4.5	110.3	4.3	554	1.3 BC	140
Apollo[a] 50SC 1.5	0.5	16.1	7.8	544	1.0 BC	667
Mitac[a] 1.5EC 1.0	0.8	31.0	2.5	68	0.8 C	0
Kelthane[a] 1.6EC 1.0	2.8	87.8	2.3	658	5.0 A	731
Late-whorl Stage Treatments:						
A1335[a] Liq.25 0.125	1.8	68.3	7.5	398	2.3 ABC	1425
A1335[a] Liq.25 0.185	1.5	54.7	7.5	804	1.0 BC	750
Comite 6.55EC 1.67	3.3	132.2	9.8	196	1.0 BC	274
Savey[a] 23%F 0.09	2.0	49.4	4.3	137	2.0 ABC	900
Apollo[a] 50SC 0.5	5.5	184.4	6.3	1859	0.0 C	0
Mitac[a] 1.5EC 0.5	2.8	99.3	7.0	315	2.8 ABC	83
Mitac[a] 1.5EC 0.75	2.3	88.3	4.8	555	1.5 BC	226
Mitac[a] 1.5EC 1.0	1.3	29.2	9.3	352	1.3 BC	307
Kalthane[a] 1.6EC 1.0	2.5	79.9	8.5	229	2.3 ABC	611
Avid[a] 0.15EC 0.02	3.5	95.5	4.5	357	0.3 C	125
ANOVA Table						
F-Value	1.01	1.03	1.21	0.77	1.82	0.72
F-Test Probability	0.46	0.44	0.29	<0.50	0.05	<0.50
Experiment CV	116	115	68	255	114	210

Means in the same column followed by the same letter are not significantly different (P = 0.05) DMRT.

[a] This product is not currently registered for use in corn.

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Table 3. Efficacy of long-residual miticides applied to corn at blister stage for spider mite control and effects on mite predators, Southwest Kansas Research-Extension Center. These treatments were applied 3 August 1988.

Treatment, formulation, and rate (lb AI/A)	Mites per 4 plants			Mite days		Predators 27 June		Predators 11 Aug.	
	27 June	11 Aug.	Percent control[a]	per 4 plants	Percent control[a]	per 4 plants	per 1000 mites	per 4 plants	per 1000 mites
Check Plot:									
Untreated --	83	39	--	1129	--	2.0	57562	1.0	13917
Post-tassel Stage Treatments:									
A1335[b] Liq.25 0.125	105	20	59	1005	30	2.0	72938	1.5	4916
A1335[b] Liq.25 0.185	126	34	43	1353	21	2.3	35600	2.0	10354
Comite 6.55EC 1.67	99	44	5	1312	3	0.5	8000	1.3	13750
Comite 6.55EC 1.67 +Cygon 4EC 0.5	81	29	24	963	13	3.0	21500	3.0	8990
Cygon 4EC 0.5	105	23	53	1052	26	4.0	29150	0.5	12000
Savey[b] 23%F 0.09	73	26	24	875	12	1.8	26063	4.0	3500
ANOVA Table									
F-Value	2.61	0.69		0.78		1.41	2.87	2.24	0.33
F-Test Probability	0.05	>0.50		>0.50		0.26	0.04	0.09	>0.50
Experiment CV	6	17		8		83	73	86	150

Means in the same column followed by the same letter are not significantly different (P = 0.05) DMRT.

[a] Percent control calculated using the Henderson and Tilton formula.

[b] This product is not currently registered for use in corn.

8-60

EFFICACY OF MITICIDES AGAINST SPIDER MITES IN CORN, 1988

L.L. Buschman and P.E. Sloderbeck

Summary

Several miticides were tested for control of Banks grass mite on furrow-irrigated corn. Mites per plant were recorded. Mite populations were low, and differences among treatments were small. The percent control of mites in the Furadan with- and without-miticide treatments suggests that Furadan had more miticidal activity than the miticides. The percent control of mites in the Cygon with- and without-additive treatments suggests that some combinations may have increased miticidal activity.

Introduction

The following trial was conducted to evaluate the efficacy of several miticides for control of the Banks grass mites (BGM), Oligonychus pratensis (Banks), in field corn.

Procedures

The trial was conducted in furrow-irrigated corn at the Southwest Kansas Research-Extension Center in Finney County, Kansas. Treatments were arranged in a randomized complete block design with four replications. The plots were four rows wide (10 ft), and 45 ft long. Treatments were applied with a high clearance sprayer using a 10 ft boom with three nozzles directed at each row (one nozzle directly over the row and one on each side of the row on 18-inch drop hoses). The sprayer was calibrated to deliver 40 GPA of water at 30 PSI of CO_2 pressure. The plot area was oversprayed with Pydrin (0.15 lb AI/A) on 4 August to control corn borers and to encourage an increase in spider mite populations. Miticide treatments were applied on 10 August.

Prior to treatment application, four plants in each plot were selected from the center two rows and flagged. The natural infestation of BGM was augmented by attaching mite-infested leaves from another corn field to the four flagged plants on 1 August. Spider mites were counted by searching all leaves on each flagged plant for large mites (primarily the adult females). Pretreatment counts were made on 3 and 9 August and a posttreatment count on 15 August. The percent TSM present in each plot was determined by collecting several mites from the flagged plants with a small vacuum sampler and mounting them for microscopic determination of species.

Results and Discussion

Mite populations were quite low and increased only a little after the Pydrin application. The spider mite population was 100% BGM (n=323). It is difficult to make meaningful inferences on the effects of the treatments,

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since there were no significant differences ($p = 0.05$) between them. However, the percent control values (calculated using the Henderson and Tilton formula, which takes into consideration the pretreatment counts) show some interesting trends. The percent control of mite populations in the Furadan and Furadan & miticide combination treatments suggests that Furadan had more miticidal activity than the miticides. The percent control of mite populations in the Cygon and Cygon-additive combination treatments suggests that some combinations may have increased miticidal activity. Supracide was unintentionally applied at half the recommended rate.

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Table 1. Efficacy of several miticides for spider mite control in corn, Southwest Kansas Research-Extension Center. Treatments were applied 10 August 1988.

Treatment, formulation, and rate (lb AI/A)	Mites per 4 plants 3 Aug.	9 Aug.	15 Aug.	Percent control[a]
Untreated Check	14.8	18.5	25.0	--
Supracide[b] 2E 0.25	13.8	25.0	18.3	46
Capture[b] 2E 0.08	12.0	21.5	17.8	39
Avid[b] 0.15E 0.02	17.8	19.5	30.3	-15
191336[c] 1.5E 0.05	9.5	15.3	13.8	33
191336[c] 1.5E 0.1	10.8	25.0	29.5	13
191336[c] 1.5E 0.2	9.0	22.8	25.8	16
Di-Syston 8E 1.0	9.5	8.8	24.8	-109
Di-Syston 8E 1.0 +Furadan 4F 1.0	8.0	25.8	14.5	58
Furadan 4F 1.0	14.8	22.5	15.3	50
Cygon 4E 0.5 +Furadan 4F 1.0	8.8	23.0	7.0	77
Cygon 4E 0.5	8.5	14.5	18.0	8
Cygon 4E 0.5 +SCI-40[d] 1.0 pt	11.0	15.8	12.0	44
Cygon 4E 0.5 +SCI-40[d] 1.0 pt +Activator[d] 90 0.25%	19.3	17.5	27.8	-18
Cygon 4E 0.5 +Activator[d] 90 0.25%	12.0	36.8	16.8	66
Cygon 4E 0.5 +LI-700[d] 1.0 pt	17.8	18.0	28.0	-15
ANOVA Table				
F-Value	0.60	1.22	0.96	
T-Test Probability	>0.50	0.30	>0.50	
Experiment CV24	14	24		

[a] Percent control calculated using the Henderson and Tilton formula.
[b] This product is not currently registered for use in corn.
[c] Applied with Codacide oil, ACD-12453, at 0.05%.
[d] SCI-40 is an acidic amendment, Sorber Chemicals, Inc., LI-700 is an acidic amendment, Loveland Industries, Inc., and Activator 90 is a spreader, penetrant, and wetting agent, Loveland Industries, Inc.

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SW Research-Extension Center
Kansas State University

EFFICACY OF STANDARD AND SIMULATED CHEMIGATION APPLICATIONS OF INSECTICIDES FOR SECOND GENERATION CORN BORER CONTROL, 1988

L.L. Buschman and P.E. Sloderbeck

Summary

Several corn borer insecticides were evaluated for control of European corn borer and southwestern corn borer on corn. Insecticides were applied by "simulated chemigation" or "standard application" techniques. Numbers of corn borer larvae and number and length of tunneling were recorded. Corn borer pressure was light, 0.6 ECB and 0.6 SWCB per plant. All simulated chemigation application treatments (except Dimilin) gave significant control of both corn borer species. Standard volume treatments generally had one or two more larvae per 10 plants then did the simulated chemigation treatments. The growth regulators (Dimilin and CME 13406) gave good control of SWCB when chemigated, but only CME gave good control on ECB. Baythroid gave excellent control of SWCB, but was less effective on ECB. Furadan gave good control of ECB, but poor control of SWCB.

Introduction

The following test was conducted to evaluate the efficacy of standard and simulated chemigation applications of insecticides for control of second generation European corn borer (ECB), *Ostrinia nubilalis* (Hubner), and southwestern corn borer (SWCB), *Diatraea grandiosella* (Dyar).

Procedures

This experiment was conducted in furrow-irrigated corn at the Southwest Branch Experiment Station in Finney County, Kansas. Treatments were arranged in a randomized complete block design with four replications. Untreated and miticide-treated (Di-Syston) check plots were included in each block. The plots were four rows wide (10 ft) and 45 ft long. The "standard applications" were made with a high clearance sprayer using a 10 ft boom with three nozzles directed at each row (one nozzle directly over the row and two suspended on 18-inch drop hoses). The sprayer was calibrated to deliver 40 GPA at 30 PSI of CO_2 pressure. The "simulated chemigation" applications were made using three Delvan 100/140, 3/4-inch rain drop nozzles mounted on the high clearance sprayer at tassel height between the rows. This system was calibrated to deliver 47 gallons in 2.4 min for each plot (5400 gallons/A). This application was equivalent to a 0.2 inch irrigation on the two middle rows. The chemicals were added to 200 gallons of water in the main tank of the sprayer, agitated by recirculation, and applied within 20 minutes of mixing. The chemicals were applied on 4 August, and some repeat treatments were made on 12 and 17 August. The timing of applications was based on the predictions of the Kansas State University phenology models for southwestern and European corn borers and the presence of corn borer eggs in the field.

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Corn borer evaluations were made between 21 and 27 September by dissecting 10 corn plants in each plot (five consecutive corn plants in each of the center two rows). The number of larvae by species and the number and length of tunneling was recorded for each plant. Unfortunately, the Banks Grass mite populations were very low and, therefore, were not counted.

Results

Corn borer pressure in the untreated plots was light: SWCB averaged 0.6 larvae per plant with 56% of the plants infested and ECB averaged 0.6 larvae per plant with 38% of the plants infested. Corn borer numbers were a little higher in the miticide check (Di-Syston) then in the untreated check,so the following comparisons are based on the former.

All of the simmulated chemigation applications (except Dimilin) gave significant control of ECB and SWCB. The standard volume applications of each chemical generally had one to two more larvae per 10 plants than the simulated chemigation applications. The standard volume applications, therefore, were not always significantly different from the check plots. Both of the growth regulators, Dimilin and CME 13406, performed well on SWCB when chemigated, but only CME 13406 performed well on ECB. Baythroid gave excellent control of SWCB, but was less effective on ECB. Furadan gave good control of ECB, but poor control of SWCB. Tunneling was significantly reduced by all of the chemicals, except the lower rates of A1335. The amount of tunneling generally correlated with the number of SWCB present, because SWCB tunnels were usually much longer than ECB tunnels.

Table 1. Effects of standard spray and simulated chemigation applications of insecticides on southwestern corn borers, Southwest Kansas Research-Extension Center, 1988. Treatments applied August 4 and then August 12 and 17 as indicated.

Treatment, formulation, and rate (lb AI/A)	4th & 5th instar SWCB: Number per 10 plants	4th & 5th instar SWCB: Percent control	All SWCB larvae: Number per 10 plants	All SWCB larvae: Percent control	SWCB infested plants: Number per 10 plants	SWCB infested plants: Percent control
Simulated Chemigation Applications:						
1.Asana 0.66E 0.04	1.75 EFGHI	68	1.75 DE	70	1.5 CD	73
2.Pydrin 2.4EC 0.15	1.0 HI	82	1.00 E	83	1.0 D	82
3.Dipel ES 2pt+2pt	2.75 CDEFGHI	50	2.75 CDE	53	2.75 BCD	51
4.Lorsban 4E 1 +1/4 +1/4	1.25 GHI	77	1.50 DE	74	1.50 CD	73
5.Lorsban 4E 1 + 1	1.5 FGHI	73	1.50 DE	74	1.50 CD	73
6.Dimilin[a] 2F 0.24	2.0 EFGHI	64	2.00 DE	66	2.0 CD	64
7.CME13406[a] 15%SC 0.24	1.5 FGHI	73	1.50 DE	74	1.5 CD	73
Standard Volume Applications:						
8.Asana 0.66EC 0.04	3.0 BCDEFGHI	45	3.00 CDE	49	2.25 CD	60
9.Pydrin 2.4EC 0.15	2.75 CDEFGHI	50	2.75 CDE	53	3.0 BCD	47
10.Dipel ES 2pt+2pt	4.75ABCD	14	5.50ABC	6	5.25AB	7
11.Lorsban 4E 1+1	3.25 BCDEFGH	41	3.25 BCDE	45	3.0 BCD	47
12.Dimilin[a] 2F 0.24	4.25ABCDE	23	4.25ABCD	28	4.0 ABC	29
13.A1335[a] 25% 0.0625	6.0A	-9	6.25A	-6	5.75A	-2
14.A1335[a] 25% 0.125	5.0ABC	9	5.50ABC	6	5.0 AB	11
15.A1335[a] 25% 0.25	2.75 CDEFGHI	50	3.50ABCDE	40	3.0 BCD	47
16.Baythroid[a] 2E 0.0375	0.5 I	91	0.75 E	87	0.75 D	87
17.Baythroid[a] 2E 0.0375 +Di-Syston 8E 1.0	0.75 HI	86	1.00 E	83	0.75 D	87
18.Furadan 4F 1.0 +Di-Syston 8E 1.0	4.00ABCDEF	27	4.25ABCD	28	3.75ABC	33
19.Furadan 4F 1.0	3.75ABCDEFG	32	4.00ABCD	32	3.75ABC	33
21.Asana 0.66EC 0.4 +Mitac[a] 1.5EC 0.125	2.25 DEFGHI	59	2.25 DE	62	2.25 CD	60
Check Plots						
20.Di-Syston 8E 1.0	5.5AB	-	5.88AB	-	5.63A	-
22.Untreated ---	5.5AB		5.50ABC		5.25AB	
ANOVA Table:						
F-Value	4.27		4.17		4.63	
F-Test Probability	<0.001		<0.001		<0.001	
CV	54		54		51	

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).

[a] This product is not currently registered for use in corn.

Table 2. Effects of standard spray and simulated chemigation applications of insecticides on European corn borers, Southwest Kansas Research-Extension Center, 1988. Treatments applied August 4 and then August 12 and 17 as indicated.

Treatment, formulation, and rate (lb AI/A)	4th & 5th instar ECB: Number per 10 plants	4th & 5th instar ECB: Percent control	All ECB larvae: Number per 10 plants	All ECB larvae: Percent control	ECB infested plants: Number per 10 plants	ECB infested plants: Percent control
Simulated Chemigation Applications:						
1.Asana 0.66E 0.04	0.75 CDE	85	1.0 CDE	82	1.0 BCD	73
2.Pydrin 2.4EC 0.15	1.5 CDE	69	2.0 CDE	64	1.5 ABCD	60
3.Dipel ES 2pt+2pt	0.5 DE	90	0.5 CDE	91	0.5 BCD	87
4.Lorsban 4E 1+1/4+1	0.25 DE	95	0.25 DE	96	0.25 CD	93
5.Lorsban 4E 1 + 1	0.25 DE	95	0.25 DE	96	0.25 CD	93
6.Dimilin[a] 2F 0.24	4.0 AB	18	5.25AB	7	3.75A	0
7.CME13406a 15%SC 0.24	0.0 E	100	0.0 E	100	0.0 D	100
Standard Volume Applications:						
8.Asana 0.66EC 0.04	2.25 BCDE	54	2.5 BCDE	56	1.75ABCD	53
9.Pydrin 2.4EC 0.15	2.5 BCD	49	3.25ABCD	42	3.0 AB	20
10.Dipel ES 2pt+2pt	1.75 BCDE	64	2.5 BCDE	56	2.75ABC	27
11.Lorsban 4E 1+1	2.0 BCDE	59	2.0 CDE	64	2.0 ABCD	47
12.Dimilin[a] 2F 0.24	1.75 BCDE	64	2.5 BCDE	56	2.25ABCD	40
13.A1335[a] 25% 0.0625	1.0 CDE	80	1.0 CDE	82	1.0 BCD	73
14.A1335[a] 25% 0.125	1.5 CDE	69	2.0 CDE	64	1.5 ABCD	60
15.A1335[a] 25% 0.25	0.25 DE	95	0.5 CDE	91	0.5 BCD	87
16.Baythroid[a] 2E 0.0375	1.75 BCDE	64	2.0 CDE	64	1.5 ABCD	60
17.Baythroid[a] 2E 0.0375 +Di-Syston 8E 1.0	1.5 CDE	69	3.0 ABCDE	47	2.5 ABCD	33
18.Furadan 4F 1.0 +Di-Syston 8E 1.0	0.5 DE	90	0.5 CDE	91	0.5 BCD	87
19.Furadan 4F 1.0	0.5 DE	90	0.5 CDE	91	0.25 CD	93
21.Asana 0.66EC 0.04 +Mitac[a] 1.5EC 0.125	1.75 BCDE	64	2.5 BCDE	56	2.5 ABCD	33
Check Plots:						
20.Di-Syston 8E 1.0	4.88A	--	5.63A	--	3.75A	--
22.Untreated ---	3.13ABC		3.63ABC		2.38ABCD	
ANOVA Table:						
F-Value	3.16		2.88		2.27	
F-Test Probability	<0.001		<0.001		0.006	
CV	91		93		95	

Means in the same column and section followed by the same letter do not differ significantly (P=0.05; DMRT).

[a] This product is not currently registered for use in corn.

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Table 3. Effects of standard spray and simulated chemigation applications of insecticides on corn borer tunneling and infested ears, Southwest Kansas Research-Extension Center, 1988. Treatments applied August 4 and then August 12 and 17 as indicated.

Treatment, formulation, and rate (lb AI/A)	Tunnel number per 10 plants	Tunneling below ear per 10 plants cm	Total tunneling per 10 plants cm	Infested ears per 10 plants
Simulated Chemigation Applications:				
1.Asana 0.66E 0.04	6.75 CDEF	59 DEF	62 CDE	0.25 B
2.Pydrin 2.4EC 0.15	3.75 F	34 EF	41 DE	0.0 B
3.Dipel ES 2pt+2pt	4.0 EF	48 EF	53 DE	0.0 B
4.Lorsban 4E 1+1/4+1/4	3.75 F	43 EF	45 DE	0.0 B
5.Lorsban 4E 1+1	3.0 F	31 EF	32 E	0.25 B
6.Dimilin[a] 2F 0.24	9.75ABCDE	77 BCDEF	84 CDE	1.0 A
7.CME13406[a] 15%SC 0.24	2.25 F	28 EF	32 E	0.0 B
Standard Volume Applications:				0.0 B
8.Asana 0.66EC 0.04	6.25 CDEF	62 CDEF	77 CDE	0.0 B
9.Pydrin 2.4EC 0.15	6.0 CDEF	81 BCDEF	84 CDE	0.25AB
10.Dipel ES 2pt+2pt	11.0 ABC	105 BCDE	114 CD	0.25AB
11.Lorsban 4E 1+1	7.5 BCDEF	76 BCDEF	80 CDE	0.25AB
12.Dimilin[a] 2F 0.24	6.5 CDEF	90 BCDEF	95 CDE	0.25 B
13.A1335[a] 25% 0.0625	9.75ABCDE	141AB	141 BC	0.0 B
14.A1335[a] 25% 0.125	10.0 ABCD	138ABCD	141 BC	0.0 B
15.A1335[a] 25% 0.25	4.5 DEF	70 BCDEF	70 CDE	0.0 B
16.Baythroid[a] 2E 0.0375	2.75 F	22 F	25 E	0.25AB
17.Baythroid[a] 2E 0.0375 +Di-Syston 8E 1.0	4.0 EF	24 F	26 E	0.0 B
18.Furadan 4F 1.0 +Di-Syston 8E 1.0	5.5 CDEF	61 CDEF	65 CDE	0.25 B
19.Furadan 4F 1.0	8.0 BCDEF	84 BCDEF	88 CDE	0.5 AB
21.Asana 0.66E 0.04 +Mitac[a] 1.5EC 0.125	6.5 CDEF	63 CDEF	64 CDE	0.5 AB
Check Plots:				
20.Di-Syston 8E 1.0	14.75A	140ABC	187AB	0.13 B
22.Untreated	12.75AB	181A	235A	0.13 B
ANOVA Table:				
F-Value	3.71	3.38	5.01	1.10
F-Test Probability	<0.001	<0.001	<0.001	0.37
CV	52	62	57	237

Means in the same column and section followed by the same letter do not differ significantly (P+0.05; DMRT).

[a] This product is not currently registered for use in corn.

CORN BORER MOTH FLIGHTS IN FINNEY COUNTY, KANSAS

M.A. Chowdhury and L.L. Buschman

Summary

Corn borer moths were monitored with a standard blacklight trap in Finney county, Kansas. The second generation ECB flight started on 16 July, and the SWCB flight started on 20 July. The flights continued into October, probably including a third generation starting about 17 August for ECB and 22 August for SWCB. The peak moth catches for both species occurred on 30 July.

Introduction

The timing of corn borer insecticide treatments is critical to the success of treatments. During the season, the timing of applications is based on the predictions of the Kansas State University corn borer phenology models and the presence of corn borer eggs in the field. Blacklight trap data are not very practical in timing insecticide treatments, but are useful for evaluating how well the treatment-timings coincide with the moth flight.

Procedures

Corn borer moths were monitored with a standard blacklight trap at the Southwest Kansas Research-Extension Center, Finney County, Kansas, May through October, 1988. Both the European corn borer (ECB), Ostrinia nubilalis (Hubner), and the southwestern corn borer (SWCB), Diatraea grandiosella (Dyar) were recorded. Only the second generation flight in July and August is presented here.

Results and Discussion

The second generation ECB flight started on 16 July, and the SWCB flight started on 20 July (Figure 1). The flights continued into October, probably including a third generation starting about 17 August for ECB and 22 August for SWCB. The peak moth catches for both species occurred on 30 July. The corn near the blacklight trap was sprayed with Asana (0.04 lb AI/A) plus Cygon (0.5 lb AI/A) on 31 July, which probably killed many moths that would have produced a larger peak somewhat later. The treatment applications for the small-plot corn borer test and the aerial Dipel test appeared to be timed quite well to control the first instars hatching from the largest oviposition periods, but there were probably substantial early and late ECB escapes. The treatment for the aerial Capture test appeared to be a bit early, but this test was about 20 miles southwest of the trap location in the sandhills, where we know that the moth flights were earlier than in the vicinity of the trap.

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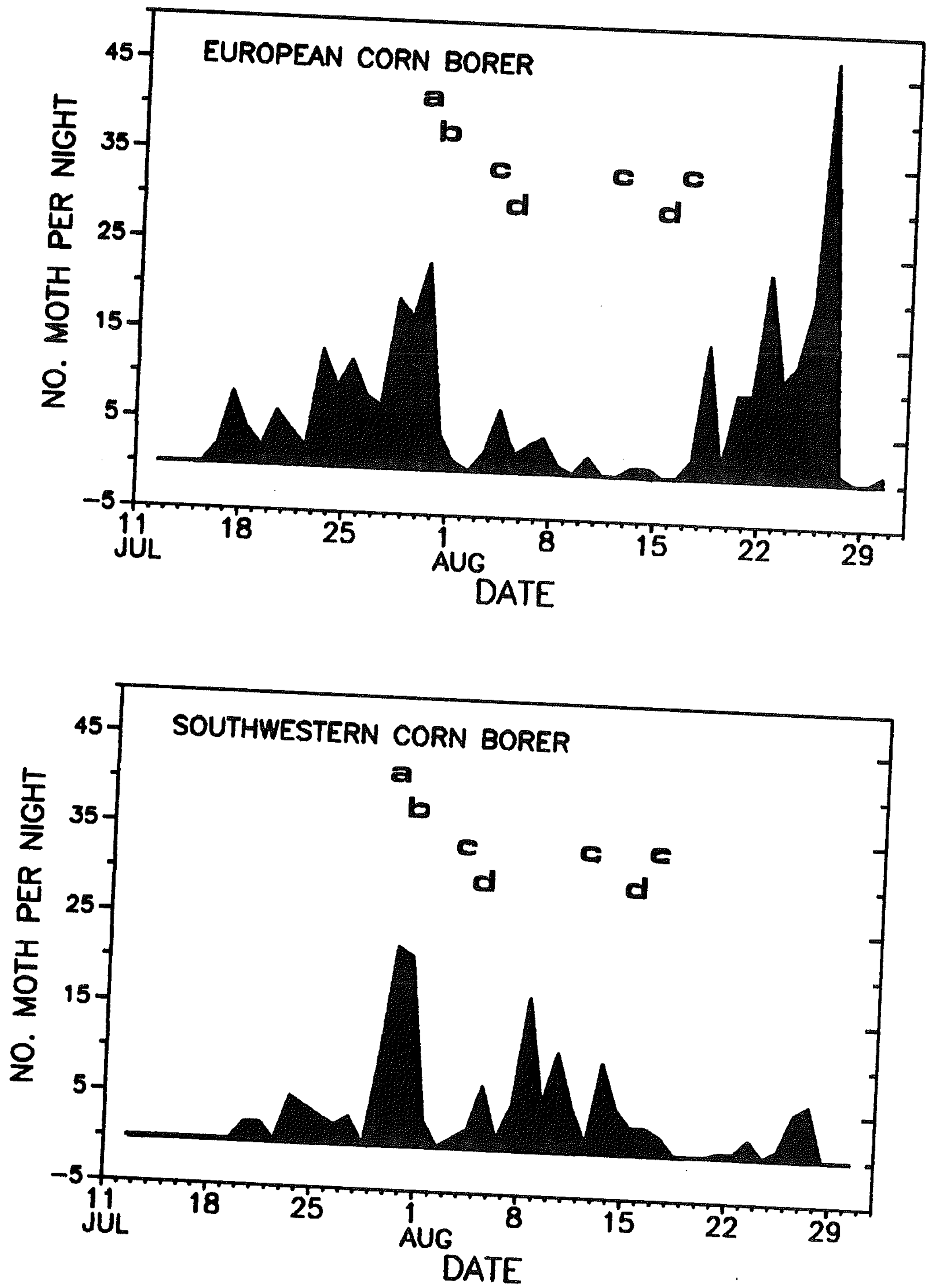
Figure 1. Blacklight trap catches of second generation European corn borer and Southwestern corn borer moths at the Southwest Kansas Research-Extension Center, 1988. The lower case letters indicate the time of different corn borer treatment applications: a. aerial Capture test (30 July), b. corn near blacklight trap sprayed (31 July), c. small plot corn borer test (4, 12 and 17 August) and d. aerial Dipel test (5 and 15 August).



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SW Research-Extension Center
Kansas State University

WOOLYLEAF BURSAGE (BUR RAGWEED) CONTROL WITH BUD, FLOWER, AND AFTER-FROST APPLICATIONS IN FALLOW[1]

Don W. Morishita and Margaret L. Steward

Summary

Several herbicides were compared for woolyleaf bursage control in fallow. Tordon + 2,4-D at 0.25 + 1.0 lb ai/A and Tordon + Banvel at 0.25 + 0.50 lb ai/A applied at the bud growth stage controlled woolyleaf bursage 99% and 98%, respectively. Woolyleaf bursage control was 91% or better with after-frost applications of Banvel at 0.50 lb/A, Garlon + Banvel at 1.0 + 0.50 lb/A, and Tordon + Banvel at 0.25 + 0.50 lb/A. Flixweed and kochia were effectively controlled with several of the herbicide treatments.

Introduction

Woolyleaf bursage, also known as bur ragweed, is a noxious perennial weed found most frequently in low lying areas of fields. It is also found in the higher areas of fields because of movement of root stocks and seeds by tillage equipment. Once established, this weed is difficult to control. The objective of this study was to compare several herbicides applied at bud, flowering, and after-frost for control of woolyleaf bursage.

Procedures

The study was established near Garden City in August, 1987. The experimental design was a randomized complete block with four replications. Herbicides were applied with a CO_2-pressurized, hand-held sprayer equipped with a six-nozzle boom. Application volume was 10 or 20 gallons per acre, depending on herbicide treatment. Herbicides were applied on August 19,1987 at bud stage; September 2, 1987 for flowering stage; and October 19, 1987, after frost. The treatments were evaluated for weed control on June 8 and July 29, 1988.

Results and Discussion

Tordon + 2,4-D at 0.25 + 1.0 lb ai/A and Tordon + Banvel at 0.25 + 0.50 lb ai/A applied at the bud stage controlled woolyleaf bursage 99 and 98%, respectively (Table 1.). Woolyleaf bursage control was 91% or better at both evaluation dates with after-frost applications of Banvel at 0.50 lb ai/A, Garlon + Banvel at 1.0 + 0.50 lb ai/A, and Tordon + Banvel at 0.25 + 0.50 lb ai/A. Fluroxypyr + Banvel at 0.75 + 0.50 lb ai/A and Garlon + Banvel at 1.0 + 0.50 lb ai/A applied at the bud stage were the most consistent herbicide treatments for kochia control. Tank mix applications of Garlon + Banvel

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[1]NOTE: The data in this report include nonregistered herbicides and/or tank mixes. Results should not be interpreted as recommendations for their application.

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applied after frost and all Tordon tank mix treatments with 2,4-D or Banvel controlled flixweed 99% or better. The same Tordon tank mixes were the only treatments that controlled Russian thistle. Overall, herbicide treatments containing Tordon best controlled woolyleaf bursage.

Table 1. Woolyleaf bursage and annual weed control in fallow near Garden City, Kansas, 1988.

			Weed control evaluation[a]						
			First				Second		
Treatment	Rate	Appl date[b]	Wlbs	Kocz	Dobr	Flwe	Wlbs	Kocz	Ruth
	(lb ai/A)		(%)						
Check	-	-	-	-	-	-	-	-	-
Banvel	0.50	10/19	95	80	81	81	95	70	35
Fluroxypyr + 2,4-D	0.25 + 1.0	8/19	46	93	79	20	45	85	36
Fluroxypyr + Banvel	0.75 + 0.50	9/2	59	99	90	59	45	95	41
Garlon + 2,4-D	0.50 + 1.0	8/19	16	65	79	25	36	64	10
Garlon + Banvel	1.0 + 0.50	8/19	45	96	64	18	23	94	13
Garlon + Banvel	1.0 + 0.50	10/19	98	48	99	99	91	30	23
Glyphosate + 2,4-D[c]	2.0 + 1.0	8/19	56	83	79	29	44	55	59
Glyphosate + Banvel	2.0 + 0.50	8/19	70	91	85	35	46	74	58
Glyphosate + Banvel	2.0 + 0.50	9/2	65	93	53	31	51	75	56
Glyphosate + Banvel	2.0 + 0.50	10/19	70	59	63	51	51	60	49
Tordon + 2,4-D	0.25 + 1.0	8/19	99	49	86	99	98	30	97
Tordon + Banvel	0.25 + 0.50	8/19	98	69	66	99	97	36	92
Tordon + Banvel	0.25 + 0.50	10/19	99	61	95	100	98	35	95
LSD (0.05)			34	36	34	42	42	35	42

[a]First weed control evaluation made 6/8/88 and second weed control evaluation made 7/29/88. Wlbs = woolyleaf bursage; Kocz = kochia; Dobr = downy brome; Flwe = flixweed; Ruth = Russian thistle.

[b]Herbicide application dates were selected to coincide with woolyleaf bursage bud stage (8/19/87), flowering stage (9/2/87), and after frost (10/19/87).

[c]All glyphosate treatments applied with 0.25% v/v nonionic surfactant.

SW Research-Extension Center
Kansas State University

SHATTERCANE CONTROL IN CORN WITH ACCENT AND BEACON[1]

Don W. Morishita and Margaret L. Steward

Summary

Two experimental herbicides, Accent and Beacon, were evaluated for shattercane control in corn. There was no significant difference in shattercane control among herbicide treatments. However, the higher rates of both herbicides controlled the shattercane best. Neither herbicide significantly injured the corn. Corn yields were generally highest with the higher rates of Beacon and Accent.

Introduction

Shattercane is a serious weed problem for corn growers. It is a highly competitive and difficult weed to control. Accent and Beacon are new, experimental, sulfonyl urea herbicides for controlling shattercane in corn. The objective of this study was to compare these two compounds at several rates and two timings of application for shattercane control in corn.

Procedures

This study was established near Montezuma, Kansas in April, 1988. The experimental design was a randomized complete block with four replications. Herbicide treatments were applied with a CO_2-pressurized, hand-held sprayer with a six-nozzle boom. The sprayer was calibrated to deliver 20 gallons per acre. Preplant incorporated herbicides were applied on May 4, 1988 and early postemergent herbicides were applied on May 17, 1988. Accent and Beacon were both applied on May 27 and June 2, 1988 at the 5- to 7- and 7- to 9-leaf shattercane growth stages, respectively. Herbicide treatments were evaluated visually for crop injury and shattercane control on June 30 and July 22, 1988. Corn yield was determined by hand harvesting a 50 ft^2 area in each plot on September 28, 1988.

Results and Discussion

None of the herbicide treatments significantly injured the crop (Table 1). Corn in some replications of the highest rate of Beacon applied at the 7- to 9-leaf growth stage showed some injury, but yield was unaffected. Shattercane control among herbicide treatments at both evaluation dates was not significantly different. Trends indicate that higher rates of Beacon and Accent applied at the 7- to 9-leaf stage were more effective for shattercane control. Corn yields ranged from 68 bu/A to 179 bu/A. The highest yields generally were obtained with the higher rates of Beacon and Accent, regardless of growth stage at application.

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[1]NOTE: The data in this report include nonregistered herbicides and /or tank mixes. Results should not be interpreted as recommendations for their application.

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Table 1. Shattercane control and corn yield near Montezuma, KS. 1988.

Treatment	Rate	Appl type[b]	Crop injury	Shca control[a] 1	Shca control[a] 2	Corn yield
	(lb ai/A)		(%)			(bu/A)
Check	-	-	-	-	-	81
Eradicane Extra	4.0	PPI	3	38	20	68
Eradicane Extra	6.0	PPI	0	41	39	104
Eradicane Extra / atrazine + Tandem[c]	4.0 / 2.0 + 0.75	PPI / 1 lf	0	39	20	106
Eradicane Extra / atrazine + Tandem	6.0 / 2.0 + 0.75	PPI / 1 lf	0	61	53	128
Lasso + Fargo	3.0 + 3.0	PPI	0	64	34	89
Beacon	0.013	5-7 lf	0	71	49	145
Beacon	0.018	5-7 lf	0	78	41	179
Beacon	0.027	5-7 lf	0	73	58	160
Beacon	0.013	7-9 lf	0	76	43	145
Beacon	0.018	7-9 lf	3	88	60	152
Beacon	0.027	7-9 lf	11	85	60	172
Accent	0.016	5-7 lf	0	58	49	118
Accent	0.031	5-7 lf	5	70	41	124
Accent	0.047	5-7 lf	3	61	46	165
Accent	0.063	5-7 lf	0	66	35	153
Accent	0.016	7-9 lf	0	75	68	164
Accent	0.031	7-9 lf	0	85	63	169
Accent	0.047	7-9 lf	0	88	69	174
Accent	0.063	7-9 lf	0	89	64	147
LSD (0.05)			ns	ns	ns	50

[a]First evaluation made 6/30/88 and second evaluation made 7/22/88.
[b]Application type corresponds to the following date: PPI = 5/4, 1 lf = 5/17, 5-7 lf = 5/27, and 7-9 lf = 6/2.
[c]Tandem combinations applied with crop oil concentrate at 1 qt/A.

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FIELD EVALUATION AND ECONOMIC ANALYSIS OF TANDEM/TRIAZINE HERBICIDE TANK MIXTURES FOR SHATTERCANE CONTROL[1]

Don W. Morishita, Margaret L. Steward, and Kevin C. Dhuyvetter

Summary

Studies were established at two locations near Montezuma and Satanta, Kansas. Shattercane control with Tandem tank mixed with either atrazine or Bladex was evaluated, as well as preplant applications of Eradicane Extra and two rates each of Accent and Beacon. Shattercane control with Eradicane Extra alone failed at Montezuma, which had a history of thiocarbamate use. All Eradicane Extra treatments with sequential applications of Tandem + a triazine herbicide controlled 80% to 90% of the shattercane on the first evaluation date. Corn yields at Satanta, which had no thiocarbamate history, were consistently higher than those at Montezuma. Eradicane Extra with sequential applications of Tandem + Bladex and atrazine + crop oil concentrate was the highest yielding treatment and had the highest economic return. Its cost was approximately $52.70 per acre. The sequential application of Tandem + atrazine or cyanazine appears to be a cost-effective shattercane control treatment, especially when corn prices are high.

Introduction

Shattercane is a major grassy weed in southwest Kansas corn fields. Shattercane infests an estimated half of the 500,000 corn acres in southwest Kansas. A need exists in this area for alternatives to control this weed. Field studies at two locations in southwest Kansas were initiated in the spring of 1988 with the following objectives: a) to compare several Tandem and triazine herbicide tank mixes for shattercane control in corn and b) to compare the economics of these treatments.

Procedures

This study was conducted at two furrow-irrigated locations in southwest Kansas. At Montezuma, thiocarbamates herbicides, primarily Eradicane, had been used previously for shattercane control. No thiocarbamates had been used recently for weed control at the Satanta location. The corn was planted on May 4 and April 28, 1988 at Montezuma and Satanta, respectively. Herbicide application dates are shown on Table 1. Herbicides were applied with a six nozzle, hand-held boom calibrated to deliver 20 gallons per acre. The experimental design at both locations was a randomized complete block with four replications. The data were analyzed statistically, and means were separated using Fisher's protected LSD. Visual evaluations of shattercane

[1]NOTE: The data in this report include nonregistered herbicides and/or tank mixes. Results should not be interpreted as recommendations for their application.

control and crop injury were taken twice; the first on June 3 and June 7 and the second on July 11 and July 15 at Santanta and Montezuma, respectively. The corn was hand harvested on September 20 and 28 at Satanta and Montezuma, respectively. Economic return of the shattercane herbicide treatments was calculated by multiplying the corn yield times a corn price ($2.50 per bushel) minus the production and harvest costs. Production costs, excluding herbicide cost, were estimated at $175 per acre, and harvest costs, based on custom harvesting prices, were $.20 per bushel.

Results and Discussion

Eradicane Extra alone failed at Montezuma, which had a thiocarbamate history, but controlled 81% of the shattercane at Satanta on the first evaluation, which was 13 to 16 days after the last treatment was applied (DALT). All Eradicane Extra with sequential applications of Tandem + atrazine or Bladex controlled 80% to 93% of the shattercane at the first evaluation. None of the herbicide treatments at Montezuma controlled shattercane by 38 DALT. Only Eradicane Extra with sequential applications of Tandem + Bladex (at spike to 1 leaf) and atrazine + crop oil concentrate (7 days later) and Accent at 0.093 lb ai/A at Satanta adequately controlled shattercane 38 DALT. Corn yields at Satanta (no thiocarbamate history) were consistently higher than those at Montezuma (thiocarbamate history). At Montezuma, plots treated with Eradicane Extra followed by Tandem + Bladex and atrazine + crop oil concentrate, Beacon at 0.018 and 0.027 lb ai/A, and Accent at 0.094 lb ai/A yielded higher than the check. At Satanta, all plots treated with Eradicane Extra with sequential Tandem + atrazine or Bladex treatments as well as all treated with Beacon and Accent yielded higher than the check.

Of those herbicide treatments whose cost was known, Eradicane Extra with Tandem + Bladex and atrazine + crop oil concentrate, the second most expensive treatment at $52.73/A, was the highest yielding treatment at each location and had the highest economic return. The sequential application of Eradicane Extra and Tandem + atrazine or Bladex appears to be a cost-effective shattercane control treatment, especially when corn prices are high.

Table 1. Timing and dates of herbicide applications for shattercane control near Montezuma and Satanta, Kansas, 1988.

Location	Satanta	Montezuma
Preplant Incorporated	4/28	5/4
Preemergence	5/9	5/9
Spike to 1 leaf	5/11	5/18
3 to 5 leaf	5/17	5/25

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Table 2. Tandem and triazine tank mixture effects on shattercane control and crop yield near Satanta, Kansas, 1988.

Treatment	Rate	Application type	Crop injury[b]	Shca control[a] 1	Shca control[a] 2	Corn yield	Economic return
	(lb ai/A)		(%)	(%)	(%)	(bu/A)	($/A)
Check	-	-	-	-	-	94	-1
EPTC 6E[c]	6.0	PPI	0	81	23	149	139
EPTC 6E / Tandem + Aatrex + COC[d]	6.0 / 0.75 + 2.0 + 1.0	PPI / Spike	0	88	68	165	155
EPTC 6E / Tandem + Aatrex + COC / Aatrex + COC	6.0 / 0.75 + 2.0 + 1.0 / 1.0 + 1.0	PPI / Spike 7 d later	0	91	62	169	162
EPTC 6E / Tandem + Aatrex + Bladex	6.0 / 0.75 + 1.0 + 1.0	PPI / Spike	0	91	69	164	151
EPTC 6E / Tandem + Bladex	6.0 / 0.75 + 2.0	PPI / Spike	0	83	78	162	194
EPTC 6E / Tandem + Bladex / Aatrex + COC	6.0 / 0.75 + 2.0 / 1.0 + 1.0	PPI / Spike 7 d later	0	92	88	192	254
Tandem	2.0	PPI	0	26	3	79	6
Tandem + Aatrex + COC / Aatrex + COC	0.50 + 2.0 + 1.0 / 1.0 + 1.0	Spike / 7 d later	0	61	10	113	106
Tandem + Bladex	0.75 + 2.0	Spike	0	45	36	144	130
Tandem + Bladex / Aatrex + COC	0.75 + 2.0 / 1.0 + 1.0	Spike / 7 d later	0	46	0	115	94
Tandem + Bladex + Dual	0.75 + 2.0 + 2.0	Spike	0	61	7	112	45
Aatrex/ Tandem + Aatrex	2.0 / 0.5 + 1.0	PPI / Spike	0	26	0	103	93
Bladex	2.0	Spike	0	24	0	100	117
Beacon	0.018	3-5 lf	0	90	71	170	-
Beacon	0.027	3-5 lf	0	90	68	161	-
Accent	0.063	3-5 lf	0	93	64	165	-
Accent	0.094	3-5 lf	0	95	92	191	-
ICI-5676	1.313	Pre	0	36	29	123	-
ICI-5676	1.75	Pre	0	9	13	108	-
LSD (0.05)			ns	35	26	56	59

[a]Shattercane control evaluated June 7 and July 15, 1988.
[b]Application type corresponds to the following dates: PPI = April 28, Pre = May 9, Spike = May 11, and 3-5 lf = May 17
[c]EPTC 6E = Eradicane Extra.
[d]COC = crop oil concentrate at 1.0 qt/A.

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Table 3. Tandem and triazine tank mixture effects on shattercane control and crop yield near Montezuma, Kansas, 1988.

Treatment	Rate	Application type[b]	Crop injury	Shca control[a] 1	Shca control[a] 2	Corn yield	Economic return
	(lb ai/A)		(%)	(%)	(%)	(bu/A)	($/A)
Check	-	-	-	-	-	72	-88
EPTC 6E[c]	6.0	PPI	0	10	3	59	-155
EPTC 6E / Tandem + Aatrex + COC[d]	6.0 / 0.75 + 2.0 + 1.0	PPI / Spike	0	90	15	114	22
EPTC 6E / Tandem + Aatrex + COC / Aatrex + COC	6.0 / 0.75 + 2.0 + 1.0 / 1.0 + 1.0	PPI / Spike 7 d later	0	80	38	112	19
EPTC 6E / Tandem + Aatrex + Bladex	6.0 / 0.75 + 1.0 + 1.0	PPI / Spike	0	88	28	105	47
EPTC 6E / Tandem + Bladex	6.0 / 0.75 + 2.0	PPI / Spike	0	86	50	124	-10
EPTC 6E / Tandem + Bladex / Aatrex + COC	6.0 / 0.75 + 2.0 / 1.0 + 1.0	PPI / Spike 7 d later	0	89	60	149	125
Tandem	2.0	PPI	0	35	2	34	-120
Tandem + Aatrex + COC / Aatrex + COC	0.50 + 2.0 + 1.0 / 1.0 + 1.0	Spike / 7 d later	0	44	31	93	8
Tandem + Bladex	0.75 + 2.0	Spike	0	80	25	112	86
Tandem + Bladex / Aatrex + COC	0.75 + 2.0 / 1.0 + 1.0	Spike / 7 d later	0	80	26	114	85
Tandem + Bladex + Dual	0.75 + 2.0 + 2.0	Spike	0	70	26	87	9
Aatrex/ Tandem + Aatrex	2.0 / 0.5 + 1.0	PPI / Spike	0	70	8	83	20
Bladex	2.0	Spike	0	0	17	58	-88
Beacon	0.018	3-5 lf	0	95	75	175	-
Beacon	0.027	3-5 lf	0	95	55	144	-
Accent	0.063	3-5 lf	0	88	34	97	-
Accent	0.094	3-5 lf	0	90	44	153	-
ICI-5676	1.313	Pre	0	0	10	68	-
ICI-5676	1.75	Pre	0	64	18	112	-
LSD (0.05)			ns	24	21	59	59

[a] Shattercane control evaluated June 7 and July 15, 1988.
[b] Application type corresponds to the following dates: PPI = May 4, Pre = May 9, Spike = May 18, and 3-5 lf = May 25.
[c] EPTC 6E = Eradicane Extra.
[d] COC = crop oil concentrate at 1.0 qt/A.

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INFLUENCE OF WEED MANAGEMENT ON ALFALFA ESTABLISHMENT, YIELD, AND FORAGE QUALITY[1]

Don W. Morishita and Margaret L. Steward

Summary

The objective of this study, started in 1987, was to determine the optimum time to initiate weed control in seedling alfalfa. The best overall weed control in 1988 was with Balan (applied PPI) followed by a sequential early postemergent application of Buctril. Pursuit, applied early postemergence, was also a good weed control treatment, but did not control field sandbur. The highest yields of alfalfa were obtained with Balan/Buctril and Pursuit treatments.

Introduction

Kansas ranks seventh nationally in alfalfa hay production, with 4 million tons annually. Southwest Kansas is a major contributor to the state's alfalfa production. High quality alfalfa is being recognized as an important part of feedlot cattle rations. In order to obtain the desired quality, a good weed management program is essential. A study was initiated in 1987 to determine the optimum time to begin weed control in relation to alfalfa establishment, yield, and forage quality.

Procedures

This study was established at the Southwest Research-Extension Center near Garden City. Alfalfa ('Riley') was broadcast seeded April 8, 1988 at a rate of 18 lb/A. Herbicide treatments included Balan applied preplant incorporated on April 8. This was followed by a sequential early postemergent Buctril application on May 20. Pursuit also was applied as a separate treatment, early postemergence on May 20. Poast + Butyrac was applied on June 2 as a late postemergent treatment. Weed control and crop injury were evaluated visually on June 23 and August 8, 1988. Forage was harvested by randomly collecting a 1-sq-meter sample from each plot, on June 23 and August 9, 1988. The alfalfa and weeds were separated by hand to determine forage yield.

Results and Discussion

None of the weed control treatments injured the alfalfa. The preplant/early postemergent application of Balan PPI followed by Buctril postemergence controlled all weed species (except johnsongrass) 86% or better

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[1]NOTE: The data in this report include nonregistered herbicides and/or tank mixes. Results should not be interpreted as recommendations for their application.

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at both evaluation dates. Pursuit applied early postemergence controlled all weed species 86% or better, except large crabgrass and field sandbur. The late postemergent application of Poast + Butyrac did not satisfactorily control redroot pigweed (first evaluation) or yellow foxtail, large crabgrass, johnsongrass, and field sandbur at the second evaluation. The treatments giving the highest alfalfa yields at the first harvest were Pursuit and Balan / Buctril. These same two herbicide treatments gave the lowest yields of broadleaf and grassy weeds.

Table 1. Crop injury and weed control evaluation in weed management systems study at Garden City, KS (second year, 1988).

Treatment	Rate	Crop injury		Weed control evaluations[a]							
				First[b]			Second[c]				
		1[b]	2[c]	Rrpw	Yeft	Kocz	Rrpw	Yeft	Lacg	Jogr	Fisb
	(lb ai/A)										
Check	-	-	-	-	-	-	-	-	-	-	-
Balan / Buctril[d]	1.125 / 0.38	0	0	99	91	100	98	86	93	78	90
Pursuit[e]	0.094	0	0	99	86	100	90	95	61	89	59
Poast + Butyrac[f]	0.20 + 0.75	4	0	61	96	94	86	61	66	5	10
LSD (0.05)		ns	ns	8	ns	4	9	12	ns	43	39

[a]Weed species evaluated were redroot pigweed (Rrpw), yellow foxtail (Yeft), kochia (Kocz), large crabgrass (Lacg), johnsongrass (Jogr), and field sandbur (Fisb).

[b]First crop injury and weed control evaluation made June 21, 1988.

[c]Second crop injury and weed control evaluation made August 8, 1988.

[d]Balan was applied preplant incorporated and Buctril was applied early postemergence.

[e]Pursuit treatment applied with 0.25% v/v nonionic surfactant.

[f]Poast + Butyrac treatment applied with 1.0 qt/A Crop oil concentrate.

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Table 2. Forage yield of weed management study in seedling alfalfa at Garden City, KS (second year, 1988).

Treatment	Rate	Forage yield: Alfalfa 1[a]	Alfalfa 2[b]	Broadleaf 1	Broadleaf 2	Grass 1	Grass 2	Total weeds 1	Total weeds 2	Total forage 1	Total forage 2	Forage composition: Alfalfa 1	Alfalfa 2	Brdlf 1	Brdlf 2	Grass 1	Grass 2
	(lb ai/A)	(lb/A)										(%)					
Check	-	881	1595	1258	38	500	529	1758	567	2639	2161	34	74	45	2	21	24
Balan / Buctril[c]	1.125 / 0.38	1310	2109	0	0	68	133	68	133	1377	2242	95	94	0	0	5	6
Pursuit[d]	0.094	1376	1834	36	10	131	361	168	371	1544	2205	89	83	2	0	8	17
Poast + Butyrac[e]	0.20 + 0.75	871	1625	675	25	17	432	692	457	1563	2082	56	78	43	1	1	21
LSD (0.05)		248	ns	611	ns	340	ns	432	ns	411	ns	17	ns	22	2	ns	ns

[a]First forage harvest taken June 21, 1988.
[b]Second forage harvest taken August 8, 1988.
[c]Balan was applied preplant incorporated and Buctril was applied early postemergence.
[d]Pursuit applied with 0.25% v/v nonionic surfactant.
[e]Poast + Butyrac applied with 1.0 qt/A crop oil concentrate.

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POSTEMERGENT WEED CONTROL IN SEEDLING ALFALFA[1]

Margaret L. Steward and Don W. Morishita

Summary

Several herbicides were evaluated for control of broadleaf and grassy weeds in seedling alfalfa. All treatments adequately controlled the broadleaf weeds but only those containing either Poast or Pursuit adequately controlled the grassy species. Those treatments controlling the grasses gave the highest alfalfa yields, best overall weed control, and the highest quality alfalfa stands.

Introduction

Control of weeds during the establishment of seedling alfalfa enhances the quality and can prolong the life of an alfalfa stand. A study was conducted to evaluate Butyrac 200, Buctril, Poast, and Pursuit alone and in combinations for the control of volunteer oats and wheat, large crabgrass, Russian thistle, and both redroot and smooth pigweed in seedling alfalfa.

Procedures

The study was conducted near Garden City, Kansas under center-pivot irrigation on a loamy fine sand. The experiment was arranged in a randomized complete block design with four replications. Plot dimensions were 10 feet by 25 feet. Herbicides were applied with a CO_2-pressurized, backpack sprayer using 11002 flat fan nozzles delivering 20 gpa at 40 psi. The seedling alfalfa was in the 2- to 4-trifoliate stage at the time of application. Visual weed control evaluations were made on June 14 and July 22, 1988. Plots were harvested on June 23 and July 26, 1988.

Results and Discussion

None of the herbicides caused any crop injury (Table 1.). All treatments controlled the broadleaf weeds 83% or better. Only those treatments containing Poast or Pursuit adequately controlled the volunteer wheat, volunteer oats, and large crabgrass. Control of the grassy species resulted in the highest alfalfa yields.

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[1]NOTE: The data in this experiment include nonregistered herbicides and/or tank mixes. Results should not be interpreted as recommendations for application.

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Table 1. Weed control and yield of alfalfa and weeds, 1988.

		Crop injury		Weed control[a]							Forage yield			
				Vooa	Vowh	Rrpw		Ruth	Lacg	Smpw	Alfalfa		Weeds	
Treatment	Rate	1[b]	2[c]	1	1	1	2	1	2	2	1	2	1	2
	(lb ai/A)	(%)									(lb/A)			
Check	-										594	2420	1972	1243
Butyrac	0.50	0	0	6	0	83	83	91	45	90	740	2057	1381	1586
Buctril	0.25	0	0	0	0	94	89	99	9	91	350	1311	1834	2256
Buctril	0.38	0	0	0	10	95	89	100	13	94	454	1693	1298	2598
Buctril + Butyrac	0.25 + 0.25	0	0	0	0	96	91	100	5	95	541	1517	1350	2508
Buctril + Butyrac	0.25 + 0.50	0	0	6	10	99	93	100	5	91	383	1987	1389	2138
Buctril + Pursuit[d]	0.25 + 0.042	0	0	100	85	100	96	100	78	99	1085	3112	147	706
Buctril + Poast[e]	0.38 + 0.30	0	0	99	96	94	94	100	93	84	1155	2566	160	1042
Pursuit	0.063	0	0	100	92	99	95	97	94	95	1326	3505	97	768
LSD (0.05) 1		ns	ns	8	14	8	ns	5	19	ns	328	783	722	84

[a]Weed species evaluated for control were: Vooa = volunteer oats, Vowh = volunteer wheat, Rrpw = redroot pigweed, Ruth = Russian thistle, Lacg = large crabgrass, and Smpw = smooth pigweed.
[b]First evaluation and harvest on 6/14 and 6/23/88, respectively.
[c]Second evaluation and harvest on 7/22 and 7/26/88, respectively.
[d]Pursuit treatments applied with 0.25% v/v nonionic surfactant.
[e]Poast treatments applied with crop oil concentrate at 1.0 qt/A.

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SW Research-Extension Center
Kansas State University

CONTROL OF TRIAZINE-RESISTANT KOCHIA IN CORN[1]

Margaret L. Steward and Don W. Morishita

Summary

This study was established to evaluate preemergent and postemergent herbicides and herbicide tank mixes for control of suspected triazine-resistant kochia in field corn. The most effective treatments were Prowl + atrazine, Accent alone, and Accent + DPX-M6316 at 0.0313 + 0.0156 lb ai/A applied at the 7- to 8-leaf stage. The three treatments of Buctril + atrazine and Marksman applied early postemergence yielded the highest total biomass of corn.

Introduction

In recent years, populations of kochia and other broadleaf weeds have developed resistance to triazine herbicides. An experiment was conducted in corn to compare several herbicides alone and in tank mixes for the control of suspected triazine-resistant kochia. Treatments included both triazine and nontriazine herbicides.

Procedures

The experiment was conducted near Garden City, Kansas in furrow-irrigated corn. A randomized complete block design with four replications was used. Plot size was 10 by 25 feet. Treatments were applied with a CO_2-pressurized, backpack sprayer using 11002 flat fan nozzles calibrated to deliver 20 gpa at 40 psi.

Preemergent treatments were applied on May 16, 1988. These included two rates of Marksman (premix of Banvel + atrazine) at 0.8 lb ai/A and 1.2 lb ai/A, two rates of Prowl + atrazine at 2.1 lb ai/A and 3.0 lb ai/A, and atrazine alone at 2.0 lb ai/A. The early postemergent (1- to 3-leaf stage) treatments were applied on June 8, 1988. These included Banvel at 0.25 lb ai/A, Marksman at 0.8 lb ai/A, three rates of Buctril + atrazine at 0.375 + 0.75 lb ai/A, 0.25 + 0.75 lb ai/A, and 0.25 + 0.50 lb ai/A, Weedar E3 at 0.0422 lb ai/A, atrazine + Tandem at 1.5 + 0.75 lb ai/A and Accent at 0.0313 lb ai/A. Three treatments of Accent + DPX-M6316 at the 5- to 6-leaf stage were applied on June 14, 1988. The rates were 0.0313 + 0.0039 lb ai/A, 0.0313 + 0.0078 lb ai/A, and 0.0313 + 0.0156 lb ai/A. These three treatments were duplicated at the 7 to 8 leaf stage on June 22, 1988.

Visual evaluations for crop injury and weed control were taken on July 6, and July 20, 1988. The corn was harvested for biomass at the silk stage of growth on July 28, 1988.

[1]NOTE: The data in this experment include nonregistered herbicides and/or tank mixes. Results should not be interpreted as recommendations for application.

Results and Discussion

The corn incurred some injury with all rates of Accent + DPX-M6316 (Table 1). This was especially evident at the earlier evaluation date. Kochia control was 90% or better at the first evaluation with all rates of Buctril + atrazine, Banvel alone, Marksman at 0.8 lb ai/A applied early post and Accent + DPX-M6316 at 0.0313 + 0.0039 lb ai/A and 0.0313 + 0.0156 lb ai/A applied at the 5- to 6-leaf stage. By the second evaluation, Accent alone, both treatments of Prowl + atrazine, and Accent + DPX-M6316 at 0.0313 + 0.0156 lb ai/A applied at the 7- to 8-leaf stage controlled kochia 91% or better. Total biomass of the corn plants were taken at the silk stage. The highest yields of corn biomass were obtained with the three Buctril + atrazine treatments and Marksman applied early postemergence.

Table 1. Control of atrazine-resistant kochia and corn biomass yields near Garden City, Kansas, 1988.

Treatment	Rate	Appl. date	Crop injury 1[a]	Crop injury 2[b]	Kochia control 1	Kochia control 2	Corn biomass yield[c]
	(lb ai/A)		(%)				(lb/A)
Check	-	-	-	-	-	-	15,500
2,4-D amine	0.4	6/8	0	8	21	11	14,500
Atrazine + Tandem	1.5 + 0.75	6/8	3	6	38	16	16,100
Atrazine	2.0	6/8	5	10	36	23	11,800
Buctril + atrazine	0.38 + 0.75	6/8	0	0	99	26	34,800
Buctril + atrazine	0.25 + 0.75	6/8	0	1	96	33	34,500
Buctril + atrazine	0.25 + 0.50	6/8	0	0	99	6	39,700
Banvel	0.25	6/8	3	1	95	74	28,900
Marksman[d]	0.8	5/16	0	5	28	60	21,100
Marksman	1.2	5/16	0	4	51	60	25,500
Marksman	0.8	6/8	3	3	97	71	33,400
Accent[e]	0.0313	6/8	0	3	81	93	29,600
Accent + DPX-M6316	0.0313 + 0.0078	6/14	38	15	85	74	24,000
Accent + DPX-M6316	0.0313 + 0.0156	6/14	9	5	90	8	21,200
Accent + DPX-M6316	0.0313 + 0.0039	6/14	9	11	90	83	21,200
Accent + DPX-M6316	0.0313 + 0.0039	6/22	16	5	54	86	18,800
Accent + DPX-M6316	0.0313 + 0.0078	6/22	20	6	79	86	24,100
Accent + DPX-M6316	0.0313 + 0.0156	6/22	23	6	84	91	25,500
Prozine[f]	2.1	5/16	0	0	35	95	29,300
Prozine	3.0	5/16	0	3	15	95	24,100
LSD (0.05)			15	9	33	23	13,200

[a]First crop injury and weed control evaluation taken 7/6/88.
[b]Second crop injury and weed control evaluation taken 7/20/88.
[c]Corn biomass yield is oven-dry weight taken at the silk stage of corn growth.
[d]Marksman is the premix package of dicamba & atrazine.
[e]All Accent treatments applied with 0.25% v/v nonionic surfactant.
[f]Prozine is the premix package of pendimethalin & atrazine.

BROADLEAF WEED CONTROL IN SOYBEANS NEAR SCOTT CITY[1]

Don W. Morishita and Margaret L. Steward

Summary

This study compared several herbicides applied preplant, preemergence, and postemergence for broadleaf weed control in soybeans ('DeKalb 283'). Tackle + Basagran injured the soybeans, but did not effect yield. Several herbicide treatments controlled redroot pigweed and puncturevine. The highest yields were obtained with Treflan, Scepter, and Pursuit treatments

Introduction

Several new herbicides are now available or will be available for weed control in soybeans. The objective of this study was to compare the application timing of imazaquin and imazethapyr as well as other postemergent herbicides for control of broadleaf weeds in soybeans.

Procedures

The study was established in a commercial soybean field near Scott City, Kansas. Soybeans were planted on May 27, 1988. The experimental design was a randomized complete block with four replications. Weed control and crop injury were evaluated visually on August 8, 1988. The soybeans were harvested with a small-plot combine on September 27, 1988.

Results and Discussion

Tackle + Basagran with and without 28% nitrogen injured the soybeans (Table 1.). No other herbicide treatment gave visual symptoms of injury. Several treatments controlled 95% or more of both redroot pigweed and puncturevine. Preplant-incorporated Pursuit applications controlled redroot pigweed and puncturevine better than postemergent applications of Pursuit; however, soybean yields were higher with the lower rate applied postemergence than the PPI applications. The highest yields were obtained with Scepter at 0.125 lb ai/A applied PPI, Pursuit at 0.063 lb ai/A applied postemergence, and Treflan at 0.50 lb ai/A applied PPI.

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[1]NOTE: The data in this report include nonregistered herbicides and/or tank mixes. Results should not be interpreted as recommendations for their application.

8-86

Table 1. Weed control and soybean yield with preplant and postemergence herbicide applications near Scott City, Kansas, 1988.

Treatment	Rate	Appl date[2]	Crop injury	Weed control[1] Rrpw	Weed control[1] Puvi	Crop yield
	(lb ai/A)		——(%)——			(bu/A)
Check	-	-	-	-	-	48
Treflan	0.50	5/21	0	81	75	62
Scepter + Lasso	0.125 + 2.0	5/21	1	98	100	61
Scepter & Prowl	0.875	5/21	0	99	100	59
Scepter & Treflan	0.875	5/21	0	99	99	61
Scepter	0.125	5/21	1	99	100	66
Scepter	0.125	6/27	1	86	96	55
Pursuit	0.063	5/21	1	99	100	53
Pursuit	0.083	5/21	1	99	96	57
Pursuit + surfactant[3]	0.063 + 0.25%	6/27	0	78	82	65
Pursuit + surfactant	0.083 + 0.25%	6/27	0	81	31	56
Pinnacle + surfactant	0.0039 + 0.25%	6/27	0	78	53	53
Pinnacle + surfactant	0.0078 + 0.25%	6/27	0	68	81	59
Cobra	0.195	6/27	0	64	78	51
Tackle + Basagran	0.50 + 0.50	7/14	4	38	49	50
Tackle + Basagran + 28% nitrogen	0.50 + 0.50 + 1.0 gal/A	7/14	15	63	70	55
LSD (0.05)			3	29	45	10

[1]Weed control and crop injury visually evaluated 8/1/88. Rrpw = redroot pigweed; Puvi = puncturevine.

[2]Application date corresponds to the following type of application. 5/21 = PPI; 6/27 = early postemergence; and 7/14 = >3 leaves.

[3]A nonionic surfactant was used.

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Kansas State University

EFFECT OF COMPOSTED MANURE AND NITROGEN FERTILIZER ON YIELD OF IRRIGATED GRAIN SORGHUM

Alan Schlegel

Summary

Preliminary results show that compost can be used as a N source by irrigated grain sorghum. A combination of compost and N fertilizer may produce greater yields than either do alone.

Introduction

This study was initiated in 1987 to determine the nutrient value of composted manure from a beef feedlot for irrigated grain sorghum production and the effect of annual compost and N fertilizer applications on soil chemical characteristics.

Procedures

Compost and nitrogen fertilizer were applied to the same plot area in 1987 and 1988. The experimental design was a complete factorial with five compost rates (0, 0.9, 1.8, 3.6,and 7.2 ton/a) and four N fertilizer rates (0, 55, 110, and 165 lb N/a). All treatments were applied and incorporated prior to planting of grain sorghum (SeedTec 701G on 6/6/87 and DeKalb DK39Y on 6/9/88). Rainfall from planting to harvest was 7.81 inches in 1987 and 8.42 inches in 1988. Irrigations were made as needed during both years. All plots were machine harvested (11/4/87 and 11/4/88), and grain yields were adjusted to 12.5% moisture.

Results and Discussion

Sorghum yields were increased by compost and N fertilizer applications (Table 1). In 1987, compost alone applied at 7.2 ton/a increased sorghum yields by 18 bu/a, whereas N fertilizer alone at 110 lb/a increased yields by 10 bu/a. Nitrogen applied at 165 lb/a tended to decrease yields. Higher yields were obtained with combinations of compost and N fertilizer than from either alone.

Yield respones to compost and N fertilizer applications were larger in 1988 than 1987. Sorghum yields were increased 50 bu/a by compost alone (7.2 ton/a) and 55 bu/a by N fertilizer alone (165 lb/a). Combinations of compost and N fertilizer increased yields by up to 75 bu/a. Each ton of compost applied in 1988 (the second year of application) increased yields by 7 bu/a. The yield responses to compost were consistent over all application rates. However, 75% of the yield response to N was observed with the lowest rate. When averaged across compost rates, yields were not increased by N fertilizer rates above 55 lb/a.

8-88

Table 1. Effect of compost and N fertilizer applications on grain yield of irrigated grain sorghum, Tribune, KS, 1987-1988.

Compost	Nitrogen rate	Grain yield 1987	Grain yield 1988
ton/a	lb/a	-------bu/a--------	
0	0	69.3	58.2
	55	71.8	99.9
	110	79.3	100.5
	165	76.6	113.3
0.9	0	69.2	64.4
	55	85.7	107.1
	110	85.0	111.1
	165	78.0	112.5
1.8	0	71.9	70.2
	55	80.7	111.6
	110	90.4	117.8
	165	84.3	107.8
3.6	0	72.3	87.3
	55	83.4	117.6
	110	85.8	125.0
	165	88.7	117.0
7.2	0	87.3	107.8
	55	95.0	121.7
	110	95.7	133.8
	165	84.9	126.6
$LSD_{.05}$		15.0	15.8
ANOVA			
Compost		**	**
Nitrogen		**	**
Compost*Nitrogen		ns	ns
MEANS			
Compost (ton/a)	0	74.2c	93.0d
	0.9	79.5bc	98.8cd
	1.8	81.8b	101.8c
	3.6	82.6b	111.7b
	7.2	90.7a	122.5a
$LSD_{.05}$		7.5	7.9
Nitrogen (lb/a)	0	74.0b	77.6b
	55	83.3a	111.6a
	110	87.3a	117.6a
	165	82.5a	115.4a
$LSD_{.05}$		6.7	7.1

8-89

EFFECTS OF NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZATION ON IRRIGATED CORN AND GRAIN SORGHUM

Alan Schlegel

Summary

Grain yields of irrigated corn and grain sorghum are increased by N and P application but not by K additions. Maximum yields have consistently been obtained with N rates of 160 lb/a on corn and 80-120 lb/a on grain sorghum. The addition of 40 lb P_2O_5/a, averaged over the past 10 years, has increased corn yields by approximately 30 bu/a and grain sorghum yields by 15 bu/a. The benefit of P additions is greater at higher N rates. Corn yields increased by 40 bu/a from P addition, when N rates were 120 lb N/a and above.

Introduction

This study was initiated in 1961 to determine responses to nitrogen, phosphorus, and potassium fertilization of continuous corn and grain sorghum grown under irrigation.

Procedures

Corn and grain sorghum were grown on Ulysses silt loam in adjacent plot areas. Fertilizer treatments were N rates of 0, 40, 80, 120, 160, and 200 lb N/a without P and K; with 40 lb P_2O_5/a and without K; and with 40 lb P_2O_5/a and 40 lb K_2O/a. Fertilizers were broadcast by hand on 8 April 1988 for corn and 11 April 1988 for grain sorghum. Corn (Pioneer 3377) was planted on 29 April, and sorghum (Golden Acres Dinero) was planted on 8 June. Rainfall from planting to harvest was 11.59 inches for corn and 8.42 inches for sorghum. All plots were irrigated prior to planting and as needed during the growing season. All plots were machine harvested (12 October for corn and 3 November for sorghum). Grain yields were adjusted to 15.5% moisture for corn and 12.5% for sorghum.

Results and Discussion

Corn yields in 1988 ranged from 59 to 172 bu/a (Tables 1 and 2). Yields increased with each additional increment of N up to 160 lb N/a. Additions of phosphorus (40 lb P_2O_5/a) increased corn yields by 35 bu/a when averaged across N rates; however, P without N did not increase yields. The benefit from P addition increased with increased N rates. At N rates of 120 lb N/a and greater, P increased yields by over 45 bu/a. Yield responses to P additions were first observed in 1965 and have been consistent ever since, particularly at N rates of 120 lb N/a and above.

8-90

Grain sorghum yields ranged from 61 to 130 bu/a (Tables 1 and 3). Sorghum yields were increased by N rates up to 120 lb N/a. Addition of phosphorus (40 lb P_2O_5/a) increased yields by 26 bu/a averaged over all N rates, but as in the corn experiment, N was required with P to get a positive response. Yield increases from P applications have been observed in this experiment for over 20 years.

Potassium applications had no effect of corn or sorghum yields in 1988. The plot area is located on a high K soil, and the effect of K has always been negligible.

Table 1. Effect of N, P, and K fertilization on grain yield of irrigated corn and grain sorghum, Tribune, KS, 1988.

Nitrogen	Corn yields P_2O_5-K_2O (lb/a) 0-0	40-0	40-40	Mean	Sorghum yields P_2O_5-K_2O (lb/a) 0-0	40-0	40-40	Mean
lb/acre				bu/acre				
0	62	59	60	60	62	61	62	62
40	86	101	103	97	76	105	108	96
80	104	128	128	120	93	112	121	108
120	98	150	144	131	90	124	129	115
160	105	172	161	146	90	130	124	115
200	107	169	169	148	99	129	130	119
Mean	94	130	127		85	110	112	
LSD.05 Nitrogen				8.9				7.5
LSD.05 P_2O_5-K_2O				6.3				5.3

8-91

Table 2. Effect of nitrogen, phosphorus, and potassium on yield of irrigated corn, 1961-1988, Tribune, KS.

			Grain yield[1]											
N	P_2O_5	K_2O	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1979-1988	1961-1988
lb/acre			bu/acre											
0	0	0	97	73	74	100	91	115	72	107	52	62	84	74
40	0	0	126	112	93	135	110	147	104	130	93	86	114	110
80	0	0	141	109	92	135	104	153	98	138	102	104	118	122
120	0	0	127	121	91	138	112	149	93	132	98	98	116	122
160	0	0	157	122	103	133	119	168	99	144	109	105	126	131
200	0	0	141	128	101	130	112	158	97	149	95	107	122	130
0	40	0	79	71	69	106	105	126	68	112	53	59	85	77
40	40	0	137	128	102	154	124	174	117	161	107	101	131	123
80	40	0	172	150	119	157	133	169	133	165	135	128	146	144
120	40	0	184	152	124	176	124	193	135	194	146	150	158	158
160	40	0	211	174	145	176	133	194	144	200	158	172	171	168
200	40	0	189	150	135	170	134	194	139	190	157	169	163	164
0	40	40	80	75	70	109	106	139	79	109	58	60	89	80
40	40	40	137	140	111	149	136	180	103	162	102	103	132	124
80	40	40	158	157	119	156	128	190	119	176	136	128	147	143
120	40	40	172	165	125	179	137	201	141	185	145	144	159	158
160	40	40	200	173	133	164	125	177	142	186	151	161	161	162
200	40	40	198	167	155	154	122	203	129	198	161	169	166	165

[1] Grain yields adjusted to 15.5% moisture.

8-92

Table 3. Effect of nitrogen, phosphorus and potassium on yield of irrigated grain sorghum, 1961-1988, Tribune, KS.

N	P_2O_5	K_2O	Grain yield[1] 1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1978-1988	1961-1988
lb/acre-								-bu/acre-							
0	0	0	87	83	62	57	73	73	90	70	103	67	62	75	73
40	0	0	100	102	84	76	114	71	97	90	108	79	76	91	94
80	0	0	106	113	97	76	108	76	111	103	115	83	93	98	107
120	0	0	100	113	98	67	106	81	106	99	104	76	90	95	105
160	0	0	113	115	104	74	105	79	100	99	114	74	90	97	104
200	0	0	102	109	105	71	114	72	111	107	101	84	99	98	107
0	40	0	85	84	60	54	87	85	94	66	99	62	61	76	75
40	40	0	104	119	90	73	120	95	117	116	137	103	105	107	107
80	40	0	110	128	122	78	134	81	109	113	141	104	112	112	116
120	40	0	121	134	130	87	132	87	119	112	137	98	124	116	118
160	40	0	119	144	119	83	128	85	129	124	149	101	130	119	121
200	40	0	116	148	123	83	129	90	123	120	144	99	129	119	123
0	40	40	92	85	65	59	103	81	86	65	96	65	62	78	76
40	40	40	100	118	105	84	114	89	112	113	134	97	108	107	107
80	40	40	114	123	110	83	129	87	118	120	146	103	121	114	118
120	40	40	119	139	120	83	135	84	116	117	134	98	129	116	121
160	40	40	119	136	124	82	129	85	106	117	147	98	124	115	120
200	40	40	119	142	113	88	131	85	121	118	140	99	130	117	119

[1] Grain yields adjusted to 12.5% moisture.

8-93

SW Research-Extension Center
Kansas State University

IRRIGATION METHODS FOR SOUTHWEST KANSAS

W. E. Spurgeon

Introduction

Water is the single most important item needed for any crop production program. Soil water is needed to provide the proper environment for nutrient absorption and uptake. Water is used to apply and may activate fertilizer as well as herbicides and pesticides. The amount of water the crop uses varies throughout the season, reaching a maximum around the pollination stage of most crops. Water has been and will continue to be a precious commodity for Southwest Kansas. Data taken by the U.S. Geological Survey indicate that between 1966 and 1987, water tables in Southwest Kansas have dropped an average of 1.3 ft. per year. With recharge rates less than 1 inch per year, it is obvious that social and economic factors will force us to use our water more wisely. Kansas laws currently limit the amount of irrigation water that can be pumped to 2 feet per acre. Also, current federal and state legislation is becoming more stringent about protecting our water quality.

Surface Irrigation

Surface irrigation is the simplest method of applying water to the soil but is usually the least efficient (40 to 60%). However, surge irrigation and automation that allows for cut back flow rates has the potential to increase efficiency substantially (possibly up to 70-80%). The efficiency is highly dependent on the infiltration rate of the soil at the time of irrigation, management, slope, and furrow length. Many farmers and researchers have reported a significant savings in water used for surge irrigation especially for the first irrigation (20 to 50%), depending on soil conditions. Since conditions change constantly, inflow rates, cutoff times, surge cycle times, and cutback times have to be monitored constantly and adjusted for optimum performance. Improved surface irrigation comes only with increased management skill and labor or automation.

Future research plans are to develop equipment and management practices that can simply and economically implement a continuous reduction in inflow rate, after the furrows have advanced to match the soil infiltration rate better. A valve similar to a surge valve needs to be developed, so it can be plumbed into a delivery system that includes a main pump, tail water pit, and tail water pump. Two valves will be needed to direct water to the field set from both pumps to provide rapid advance. Then pumps and valves will be operated to continuously reduce the inflow. Since the main pump will run all the time, excess water pumped from the main pump will be stored in the tail water pit.

8-94

Sprinkler Irrigation

Sprinkler irrigation, particularly center pivot and linear move systems, provides a more efficient method of applying water, about 75-90 %. Typical systems are affected by weather conditions. Low energy precision application (LEPA) was developed by researchers at Texas A & M University. A LEPA system uses drop hoses to deliver water to the soil with nozzles spaced about every 5 ft. at a height of 1 ft. above the soil surface. The advantages of LEPA include less energy needed to propel the system (wheel tracks stay dry) and less energy needed to pressurize the water, since the nozzles are rated at only 6 psi. New spray heads enable the system to have a spray up or chemigation mode, which allows for better insect control with less chemical. Nozzles can apply water in a flat spray for germination, also. LEPA is considered to be about 95% efficient. However, furrow diking and/or deep ripping is needed to prevent runoff because application rates are higher with a wetted radius of less than 5 feet.

Current research is underway to evaluate the performance of a LEPA system located at the Research Extension Center. The equipment was funded by the Southwest Ground Water Management District #3. The study includes an analysis of frequency and amount of irrigation. Irrigations will be scheduled by inputting climatic data into an irrigation scheduling program developed by the USDA-Agricultural Research Service. The amount of water applied will be 40%, 70%, 100%, and 130% of the estimated crop water use. Plots will be irrigated at 3, 6, and 9 day frequencies. The amount of water applied will be based on previous treatments. For example, if corn uses 0.25 inch of water per day, then the 3 day 100% of estimated crop water use plot will receive 0.75 inch every 3 days and the 9 day 100% plot will receive 2.25 inches every 9 days. Yield data will be taken to determine if we can maintain or increase yields with the same or smaller amounts of water.

Drip Irrigation

The most efficient method of replenishing soil water is by drip irrigation (buried drip lines). This method can be nearly 99% efficient, if it is managed to prevent all excess leaching below the crop root zone. Currently, drip irrigation is the most expensive method. At least $350/acre is needed for basic equipment and more is required for longer lasting systems (systems with flush lines), installation costs, and injection equipment needed for cleaning and maintaining drip lines.

About a one acre of land at the Research-Extension Center is dedicated to a drip line spacing study. Corn rows will be planted perpendicular to drip lines buried (6 inches) below the soil surface and spaced from 2.5 feet to 10 feet apart. This will allow us to determine potential yields from a variety of drip line spacings. Drip irrigation is most economical on high value crops, such as cotton, fruits, and vegetables.

8-95

Comparison of Systems

Corn in Southwest Kansas can require about 20 to 24 inches of water per season. If 6 inches of precipitation is received during the growing season and the total crop water use is 24 inches, then the amounts needed to be applied by the various methods are as follows (net amount needed = 24-6 = 18 inches):

Irrigation Method	Gross Amount Applied
Surface (60%) efficient	30.0
Sprinkler (85%) efficient	21.2
LEPA (95%) efficient	18.9
Drip (99%) efficient	18.2

These generalized values indicate that keeping within the allowed limit of 24 inches may be difficult with surface methods. Adequate water rights will be needed to operate the less efficient systems or a limited irrigation management program will need to be implemented. Even less water may be required by the LEPA and Drip Systems because of the ability to apply the water to the soil more precisely and at the right time.

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MILKWEED AS A CROP

Merle Witt

Introduction

Milkweed is one of approximately 3,000 different kinds of plants that have been grown for human benefit. The number 3,000 seems large until we realize that there are an estimated 240,000 plant species on earth. We've not used much over 1% of the plants that are potentially available to us.

Milkweed is a native of North America and generally is considered as a weed. It is a persistent perennial and propagates both by underground vegetative buds and by wind-borne seeds. However, it was an extremely useful plant during World War II, when 1.2 million life jackets were manufactured by using the floss from 25 million pounds of milkweed follicles.

Research on milkweed floss has recently identified it as being a long lasting and high insulative product equal to goose down for use in thermal garments. Thus, its future depends upon agronomic productivity and economic realities.

Results

Milkweed variety and hybrid trials were begun in 1985 at Garden City to evaluate floss production and other characteristics. 1988 agronomic data for 15 varieties are given in Table 1 and for 35 hybrids in Table 2.

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Table 1. 1988 Milkweed variety trial, Garden City, Kansas.

Entry	Bloom Date	Height inches	% Lodge	Stems dry lbs/A	Pods dry lbs/A	Floss lbs/A	Floss Dry mg/pod	Seed lbs/A
KS3503	6-10	58	7	5814	1226	248	528	343
ND3396	6-3	43	25	5244	1798	345	530	732
MT3482	6-3	45	13	5575	1180	218	744	526
KS3502	6-10	51	3	6732	1730	374	705	545
NM3507	6-5	50	52	6126	1325	305	775	507
OR3473	6-9	38	43	3217	1203	265	575	437
ID3390	6-6	40	27	2632	1024	221	761	423
KS3501	6-9	50	33	6771	1889	440	797	680
CO3397	6-5	52	45	6314	841	163	717	355
WA3391	6-4	45	57	5381	1368	283	673	583
UT3385	6-6	53	38	6249	1979	441	745	807
CO3398	6-6	57	13	9830	1084	241	777	390
MA3381	6-8	54	13	7274	2021	449	599	709
CO3399	6-4	53	62	7690	1967	413	829	804
Bulk	6-7	49	47	6770	1947	452	805	804
Avg.	6-6	49	32	6108	1505	324	704	576
LSD(5%)	2.8	6.3	35.4	2127	620	133	127	226
C.V.%=	1.0	7.6	66.5	20.8	24.6	24.5	10.8	23.5

*Irrigated plots established from seed planted May 30, 1985.
1988 harvest date - August 3-4.

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Table 2. 1988 Milkweed hybrid trial, Garden City, Kansas.

Entry	Bloom Date	Height inches	% Lodge	Stems dry lbs/A	Pods dry lbs/A	Floss lbs/A	Floss Dry mg/pod	Seed lbs/A
1158	6-8	46	68	4592	2166	502	1177	799
1200	6-9	45	60	4273	1671	368	737	565
1161-b	6-11	51	10	5685	1665	406	861	605
1166-b	6-8	52	15	7577	2490	538	689	949
1156	6-9	48	50	5499	2805	614	743	940
1167	6-9	49	15	6895	2545	669	805	855
1191	6-9	46	55	5462	1790	414	951	668
1182	6-11	52	25	9797	4145	863	975	1550
1204-b	6-9	48	25	4510	1965	444	908	714
1205-a	6-11	48	3	5344	1674	407	923	506
1166-a	6-11	49	15	6745	2720	547	688	895
1170	6-13	44	8	5346	1892	492	850	700
1175	6-10	51	35	3953	1878	389	675	665
1160	6-13	52	10	6672	2041	433	624	747
1177	6-10	48	35	4922	2259	538	831	728
1155	6-10	50	20	5340	2615	675	865	984
1204-x	6-11	50	10	6357	2155	478	1088	728
1161-c	6-11	52	18	6058	2956	612	768	1014
1161-a	6-9	45	60	5823	2770	659	859	1097
1205-b	6-13	53	15	4665	1563	250	619	553
1159	6-12	50	38	6498	2324	618	1035	758
1171-0	6-12	54	10	7198	1778	357	856	526
1204-a	6-8	49	80	5396	2731	522	703	1090
1194	6-10	50	8	5204	1886	348	745	536
1171-3	6-11	54	8	7616	2306	604	1224	798
1163	6-8	52	50	7633	2776	711	968	961
1168	6-10	50	10	6954	2224	452	852	903
1200-1201	6-10	46	70	5196	1936	382	633	740
1181	6-12	51	10	6826	1720	358	686	655
1206	6-7	48	35	5434	2469	568	920	881
1164	6-10	50	30	7591	3011	561	806	997
1202	6-11	46	90	2666	1408	348	862	451
1187	6-8	47	90	4703	2866	636	867	929
1201	6-10	47	75	4057	1720	353	562	585
1169	6-13	47	75	3550	1878	404	839	712
Avg.	6-10	49	35	5787	2251	500	834	794
LSD(.05)	3.00	N.S.	38.4	2471.2	1063.4	238.2	167.34	379.76
CV%	.91	6.10	53.89	21.04	23.27	23.46	9.89	23.57

*Irrigated plots established from seed planted May 30, 1985.
1988 harvest date - August 16-19.

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WHEAT RESPONSE TO LATE PLANTING DATES

Merle Witt

Planting of winter wheat is often accomplished during the most recommended period of September 15 to October 5. However, some situations preclude planting at that time, such as lack of surface moisture, planting after another crop is harvested, and the uncertainty of federal farm programs. Normal to very late planting dates have been evaluated in this study to provide information on wheat production potential as planting dates are delayed.

Results are given in Table 1. Major conclusions are:

(1) Yields decline progressively with planting dates after October 1.

(2) Little head/grain formation may occur when planting is later than February 1.

(3) Planting rates must be increased with later planting dates.

Table 1. Wheat response to late planting dates, Garden City, KS, 1988.

Date planted	Date headed	#Spikelets/ head	Plant height	Test wt.	Yield, Bu/A 1988	Yield, Bu/A 4 yr. av.
Oct. 1	5-14	10.8	24	59.6	47.4	47.4
Nov. 1	5-17	11.1	21	59.4	33.9	37.5
Dec. 1	5-23	11.3	20	57.0	24.7	32.0
Jan. 1	5-26	11.4	20	54.0	20.0	27.9
Feb. 1	5-28	11.7	20	51.2	15.4	24.0
March 1	6-1	11.1	18	44.9	10.1	9.7
April 1	--	--	5	--	0.0	0.0

Av. = 21.6
L.S.D.(5%) = 4.4
C.V. % = 8.3

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EFFECT OF REDUCED AND NO TILLAGE ON SOIL MOISTURE STORAGE DURING FALLOW AND YIELD OF GRAIN SORGHUM IN A WHEAT-SORGHUM-FALLOW ROTATION

Charles Norwood

Summary

Reducing tillage in the wheat-sorghum-fallow rotation resulted in an increase in the amount of soil moisture stored during fallow and an increase in the yield of dryland grain sorghum.

Introduction

A long-term study is being conducted to determine the effects of reduced and no tillage on grain sorghum. The effects of these tillage systems on soil moisture storage and yield also are being studied.

Procedures

Grain sorghum was grown after an 11-month fallow period following wheat in a wheat-sorghum-fallow rotation for 3 years beginning in 1986. Treatments were conventional tillage, minimum tillage, and no tillage. No herbicides were applied during fallow in the conventional treatment, and blading was used as necessary for weed control. Three lbs/A propachlor + 1.0 lbs/A atrazine were applied preemergence for weed control in the growing sorghum. Both the minimum and no-till treatments received 2 lbs/A atrazine following wheat harvest in each of the 3 years of the study. The minimum-till plots were bladed at least once prior to planting (Table 1), and then received 3 lbs/A propachlor + 1.0 lb/A atrazine preemergence to the sorghum. The no-till treatment received 1.6 lbs/A cyanazine + 1.0 lbs/A atrazine early preplant in the spring of 1986 and 1987, and 1.6 lbs/A cyanazine in the springs of 1988. In addition, the no-till plots received 5 lbs/A propachlor preemergence in 1986 and 1987 and 3 lbs/A propachlor + 1.0 lbs/A atrazine preemergence in 1988.

The soil type was a Richfield silt loam having a pH of 7.8 and an organic matter content of 1.5%. The experimental design was a randomized block with three replications.

Results and Discussion

The number of tillage operations necessary for weed control in each of the 3 years is given in Table 1. The conventional treatment was bladed once or twice after wheat harvest and an additional one or two, times as necessary, in the spring prior to planting. The use of atrazine resulted in the elimination of all tillage during the summer of wheat harvest in the minimum- and no-till treatments. In 2 of the 3 years, the minimum-tillage treatment required tillage only once prior to sorghum planting because there

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was no early growth of weeds. In 1986, two operations were necessary for weed control in the minimum-till treatment. The no-till treatment resulted in near perfect weed control in all 3 years. An infestation of johnsongrass necessitated the use of propachlor and atrazine preemergence in the no-till plots; otherwise, preemergent treatments probably would not have been needed.

The data in Table 2 indicate that reducing tillage resulted in additional storage of soil moisture. The largest increment usually occurred in the minimum-till plots. The no-tillage treatment did not result in significant, additional storage of moisture. However, in 1986 the only significant difference occurred between the conventional and no-till treatments.

The yield of sorghum (Table 3) followed the pattern of stored moisture in 1987 and 1988, i. e. significant yield increases occurred with either minimum- or no-tillage systems, but there was no significant advantage for no tillage over minimum tillage. There were no significant yield differences between treatments in 1986.

Table 1. Effect of tillage system on the number of tillage operations prior to grain sorghum in a wheat-sorghum-fallow rotation, Garden City, KS.

Tillage system	1986	1987	1988	Average
Conventional	3	3	4	3.3
Minimum	2	1	1	1.3
No till	0	0	0	0.0

Table 2. Effect of tillage on the amount of available soil moisture stored by time of sorghum planting in a wheat-sorghum- fallow rotation, Garden City, KS.

Tillage system	1986	1987	1988	Average
	Inches available water in a 5 foot profile			
Conventional	1.46	3.51	4.87	3.28
Minimum	2.07	6.48	6.60	5.05
No till	2.76	5.34	7.30	5.13
		lsd (0.05)	0.85	

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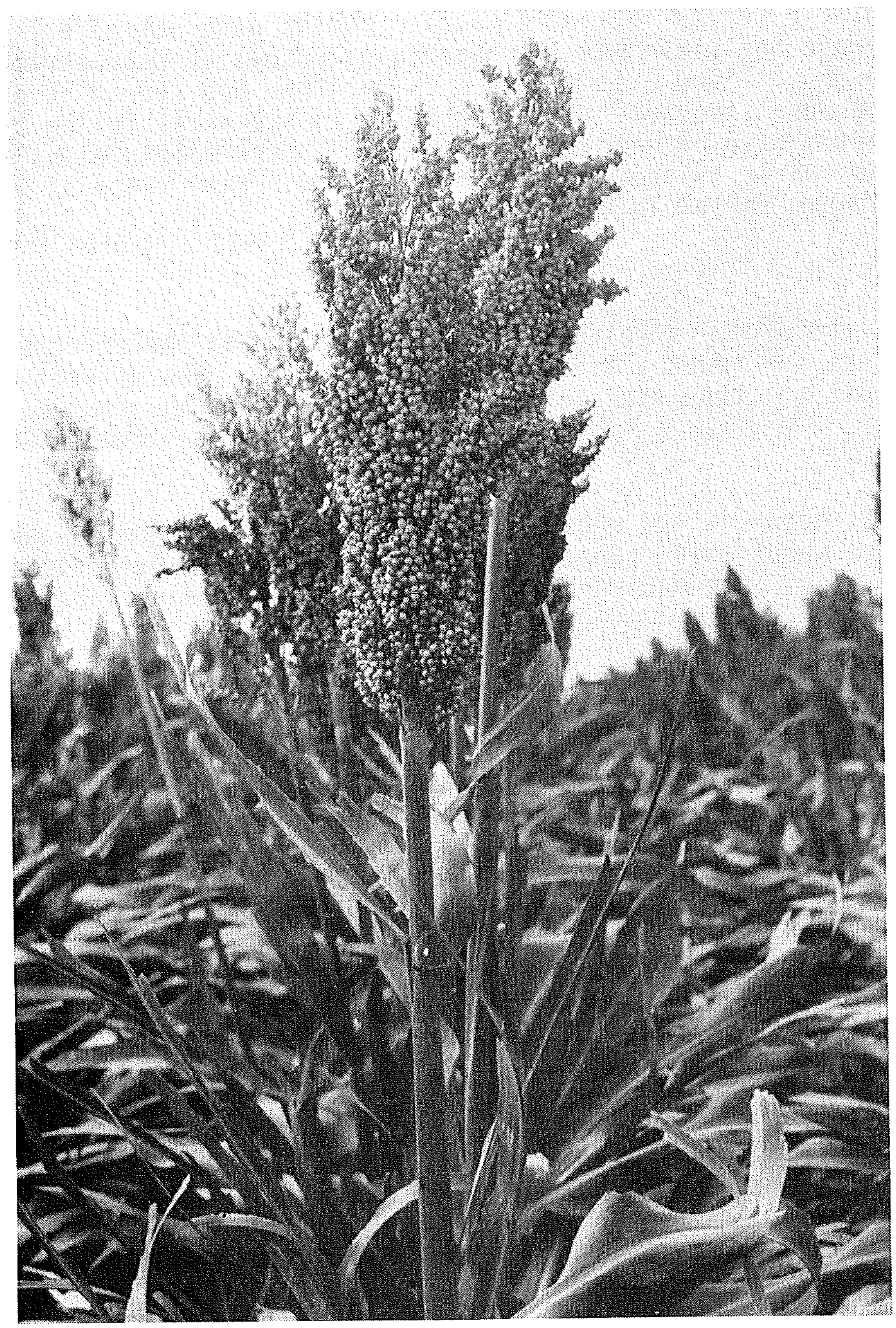
Table 3. Effect of tillage on the yield of grain sorghum in a wheat-sorghum-fallow rotation, Garden City, KS.

Tillage system	1986	1987	1988	Average
		-Bu/A-		
Conventional	69.2	49.2	35.3	51.2
Minimum	71.0	61.5	49.0	60.5
No till	63.1	69.2	51.6	61.3
		lsd (0.05)	8.8	



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EFFECT OF CROPPING SYSTEM AND REDUCED TILLAGE ON SOIL MOISTURE STORAGE DURING FALLOW AND YIELD OF WINTER WHEAT

Charles Norwood

Summary

Reduced tillage in the wheat-fallow system resulted in additional storage of precipitation in 1 of 2 years. Yields were not affected. Neither moisture storage nor yield was increased as a result of reduced tillage in the wheat-sorghum-fallow system. As much moisture was stored in during fallow in the wheat-sorghum-fallow system as in the wheat-fallow system, and yields did not differ between the two systems. Less moisture was stored in the continuous wheat system, and yields were lower than those of wheat-fallow and wheat-sorghum-fallow in 2 of 3 years.

Introduction

A long-term study is being conducted to determine the effects of cropping system and reduced tillage on winter wheat. The effects of reduced tillage on soil moisture storage and yield also are being studied.

Procedures

Wheat was grown in the wheat-fallow (WF), wheat-sorghum-fallow (WSF), and continuous wheat (WW) cropping systems. The systems have different combinations of tillage and herbicides. Glean is no longer labeled for use in western Kansas.[1]

<u>WF</u>

1. Conventional- Blade only

2. Reduced- 1.0 lb atrazine postharvest + tillage as needed.

3. Reduced- 1.0 lb atrazine postharvest + (2.0 lbs Bladex + 0.125 oz Glean) in the spring + tillage as needed.

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[1]Glean has been removed from the market in western Kansas because of the development of resistant weed species. For in crop weed control, herbicides such as 2,4-D or dicamba can be used. Ally can be used for postemergent, in-crop weed control only if it is tank mixed with a hormone type herbicide. Ally cannot be used during fallow.

4. Reduced- 0.375 oz Glean in-crop to wheat + 1.0 lb atrazine postharvest + (2.0 lbs Bladex + 0.125 oz Glean) in the spring + tillage as needed.

5. No till- 0.375 oz Glean in-crop to wheat + 1.0 lb atrazine postharvest + (2.0 lbs Bladex + 0.125 oz Glean) in the spring + postemergent herbicides as needed.

<u>WSF</u>

1. Conventional- Blade only

2. Reduced- 2.0 lbs Bladex + 0.125 oz Glean in the spring + tillage as needed.

3. No till- 2.0 lbs Bladex + 0.125 oz Glean in the spring + postemergent herbicides as needed.

<u>WW</u>

1. Conventional- Blade only

2. No till- 0.375 oz Glean in-crop + postemergent herbicides as needed.

Landmaster, paraquat, or 2,4-D, depending on the weed species present, were used when the residual herbicides no longer controlled weeds. These herbicides also were used with the residual herbicides, if large weeds were present at application.

Soil moisture was measured at 1-foot increments to a depth of 5 feet after harvest and at planting. Larned wheat was planted with a John Deere HZ no till drill. The soil type was a Richfield silt loam with a pH of 7.8 and an organic matter content of 1.5%. The experimental design was a randomized block with three replications.

Results and Discussion

<u>Soil moisture</u>. The amount of soil moisture present at planting time in the WF and WSF systems is presented in Table 1. There was 0.8 inch more moisture in the 1988 WF no-till treatment than in conventional tillage. No other differences occurred. In Table 2 is a comparison between the WF, WSF, and WW cropping systems averaged over tillage treatments. There were no differences between the WF and WSF systems in terms of moisture stored. Less moisture was stored in the WW system only for the 1987 crop. Moisture storage for the 1988 crop was greater than usually expected because of greater than normal rainfall in June and July of 1987.

<u>Yield</u>. Tillage had no significant effect on wheat yields in either the WF (Table 3) or WSF (Table 4) systems. Yields were low in 1987 because of lodging and in 1988 because of drought, insects, and disease. Thus, the added moisture stored in the WF no-till treatment did not result in additional yield. Continuous wheat yields are presented in Table 5. As with WF and WSF, tillage treatment had no effect on yield.

A summary of the yield data is presented in Table 6. In 1986, WW yielded as much as WF,and in 1988, 76% as much, but only 46% as much in 1987. There were no differences between WF and WSF in any year. WW yielded as well as WF in 1986 because greater than normal rainfall occurred in July, August, and September of 1985. There were no WSF plots in 1986, because the study was not started until after wheat harvest of 1984.

The data from this study confirm data from other studies at both Garden City and Tribune that, if sorghum is considered, yields from the WSF system will equal and often exceed yields from the WF system.

Economics of herbicide application. The cost of herbicides in reduced tillage systems will vary considerably depending on the herbicides used and the number of applications needed for satisfactory weed control. Another factor to consider is the reduction in tillage. One application of almost any herbicide will cost more than a single tillage operation. Therefore, two or more tillage operations should be eliminated by using a single herbicide application. Table 7 shows costs of herbicides (including $3.50 per acre for custom application) vs. the number of tillage operations eliminated for some of the currently labeled treatments. Also included are the treatments for sorghum in the WSF system discussed in the preceding section.

The cost of multiple applications can easily exceed $20 per acre. Three or more tillage operations can eliminated in the WF system by applying 1 lb atrazine postharvest followed by 2.4 lbs Bladex. This treatment and the other treatments involving multiple applications are too expensive, even with the reduction in tillage, unless an increase in yield results. Yield increases in WF from reduced tillage usually have not occurred at Garden City. A single pound of atrazine alone, however, followed by tillage when needed, can result in the elimination of up to 3 tillage operations and costs only $5.60. If rain does not occur within 3 or 4 weeks following, application, the atrazine may not result in satisfactory weed control. However, the cash outlay of $5.60 is relatively small and tillage can still be used economically to control escaped weeds.

In the WSF system prior to wheat, Bladex used in spring will result in 30-45 days weed control. However, the cost of $15 is too expensive, as is the $25+ necessary to obtain no-till wheat in WSF. Landmaster or Cyclone (paraquat) are probably more economical. Although these herbicides offer no soil residual, sometimes more than one tillage operation can be eliminated because there is less mixing of the soil (which plants weed seed) than with a complete tillage system. Landmaster or Cyclone also can be used in the WF system.

The best application of reduced or no tillage is in the WSF system prior to sorghum. In the WSF system, 2 lbs atrazine after harvest costs $7.70. This rate usually will result in adequate weed control into the following spring, even in dry years. The addition of 1.6 lb Bladex in the spring usually allows a no-till system. The $20.76 cost is more than offset by eliminating all tillage and a resulting increase in yield, in most years.

Although the cost of herbicides is a major factor in reduced- or no-till systems, other factors must be considered. One is a savings in labor. When tillage operations are eliminated, allowing other tasks can be performed. For example, summer fallow may need to be tilled when sorghum needs to be planted. Herbicides can eliminate the need for tillage at this time. Weeds are usually difficult to control in the spring because of wet soil. Control of weeds with herbicides can eliminate this problem.

The preceding is a general discussion of the costs of reduced tillage. An economist should be consulted to determine a more detailed evaluation for an individual farm.

Table 1. Effect of cropping system and tillage on the amount of available soil moisture stored by wheat planting time, Garden City, KS.

Cropping system	Tillage system	1987	1988	Avg
			-Inches-[1]	
Wheat-fallow	Conventional	7.1	6.2	6.6
Wheat-fallow	No-till	6.7	7.0	6.8
Wheat-sorghum-fallow	Conventional	6.0	5.5	5.7
Wheat-sorghum-fallow	No-till	6.2	5.8	6.0
lsd (0.05)	Cropping system	ns	ns	ns
	Tillage system	ns	0.4	ns

[1]Inches available water in a 5 ft profile

Table 2. Effect of cropping system on the amount of available soil moisture stored by wheat planting time, Garden City, KS.

Cropping system	1987	1988	Avg
		-Inches-[1]	
Wheat-fallow	6.9	6.6	6.7
Wheat-sorghum-fallow	6.1	5.6	5.8
Continuous wheat	2.9	5.6	5.8
lsd (0.05)		1.2	

[1]Inches available water in a 5 ft profile

Table 3. Effect of tillage on the yield of winter wheat in a wheat-fallow system, Garden City, KS.

Tillage system	1987	1988	Avg
		-Bu/A-	
Conventional	24	19	21
1.0 lb atrazine(P)[1] + tillage as needed	27	22	24
1.0 lb atrazine(P) +(2.0 lbs Bladex + 0.125 oz Glean)(S) + tillage as needed	26	22	24
0.375 oz Glean(I) + 1.0 lb atrazine(P) +(2.0 lbs Bladex + 0.125 oz Glean)(S) +tillage as needed	26	22	24
0.375 oz Glean(I) + 1.0 lb atrazine(P) + (2.0 lbs Bladex + 0.125 oz Glean)(S) + postemergent as needed: NO TILL	27	19	22
lsd (0.05)		ns	

[1] I = applied incrop to wheat
P = applied postharvest
S = applied in spring

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Table 4. Effect of tillage on the yield of winter wheat in a wheat-sorghum-fallow system, Garden City, KS.

Tillage system	1987	1988	Avg
		-Bu/A-	
Conventional	24	25	25
Minimum	26	23	24
No till	23	19	21
lsd (0.05)		ns	

Table 5. Effect of tillage on the yield of continuous winter wheat, Garden City, KS.

Tillage system	1987	1988	Avg
		-Bu/A-	
Conventional	10	17	14
No till	13	14	14
lsd (0.05)		ns	

Table 6. Effect of cropping system on the yield of winter wheat, Garden City, KS.

Cropping system	1986	1987	1988	Avg
		-Bu/A-		
Wheat-fallow	28	26	21	25
Wheat-sorghum-fallow	--	24	23	(23)
Continuous wheat	30	12	16	19
lsd (0.05)		4		

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Table 7. Cost of herbicides for use in fallow vs. reduction in tillage, Garden City, KS.

Cropping system	Herbicides	Cost[1]	Reduction in number of tillage operations
WF[2]	1 lb atrazine (P)[3]	$5.60	2-3
WF	1 lb atrazine (P) + 2.4 lbs Bladex(S)	20.57	3-4
WF (No till)	1 lb atrazine(P) + 2.4 lbs Bladex(S) + postemergent as needed	30+	all:5-7
WSF(W)	2.4 lbs Bladex(S)	14.97	2
WSF(W) (No till)	2.4 lbs Bladex(S) + postemergent as needed	25+	all:3-4
WF or WSF	40-54 oz Landmaster	9.27-11.31	1-2
WF or WSF	0.375-0.5 lb Cyclone	9.12-11.00	1-2
WSF(Sor)	2 lbs atrazine(P)	7.70	2-3
WSF(Sor) (No till)	2 lbs atrazine(P) + 1.6 lbs Bladex(S)	20.76	all:3-4

[1]Cost includes price of herbicide + $3.50 for application
[2]WF = Wheat-fallow; WSF = Wheat-sorghum-fallow
[3](P) = Postharvest; (S) = spring; (W) = wheat; (Sor) = sorghum

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DRYLAND VS. IRRIGATED CROPPING SYSTEMS

Charles Norwood

Summary

Dryland wheat, corn, and sorghum yielded 30, 36, and 63 Bu/A, respectively. One irrigation resulted in yields of 38, 52, and 91 Bu/A for the same crops. Wheat and corn yields were reduced by insects, disease, and drought. Sorghum tolerated the drought much better and produced good yields.

Introduction

A study was initiated in the fall of 1987 to compare dryland cropping systems with cropping systems receiving limited irrigation. The objective of the study is to develop cropping systems adapted to limited irrigation and prevent a return to dryland systems in areas that have had large declines in groundwater and/or large increases in pumping costs.

Procedures

Treatments are as follows:

1. Dryland wheat-fallow-dryland sorghum and corn
2. Irrigated wheat-fallow-dryland sorghum and corn
3. Irrigated wheat-fallow-irrigated sorghum and corn
4. Dryland wheat-fallow-irrigated sorghum and corn
5. Irrigated wheat-fallow-dryland wheat-continuous irrigated wheat
6. Continuous irrigated wheat
7. Continuous dryland wheat
8. Continuous irrigated sorghum and corn
9. Continuous dryland sorghum

Thus, complete dryland wheat-sorghum or corn-fallow (WSF or WCF) systems are included as are treatments, in which either wheat or sorghum(corn) or both are irrigated (treatments 1-4). The plots are split into half corn and half

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sorghum, and each crop receives the same irrigation treatment. Treatment 5 is an alternate irrigated-dryland wheat system. There are 15 months of fallow between the irrigated and dryland wheat, and then irrigated wheat is cropped continuously after the dryland wheat. One objective of this and the other irrigated wheat-fallow treatments is to produce more straw than in the dryland wheat-fallow system and store more moisture during fallow. Treatments 6 through 9 are continuous crops. Continuous dryland corn is a near impossibility and is not included.

The irrigation treatments consist of one in-season irrigation at about boot or silking stage in the WSF and WCF systems. Wheat is irrigated after jointing to prevent lodging. The continuous crops receive a pre-irrigation in addition to the in-season irrigation. Fallow is intended to replace pre-irrigation in the other treatments.

Varieties planted in 1987-88 were Dodge wheat, Garst 8762 corn, and DeKalb DK-46 grain sorghum. Wheat was planted in 10-inch rows on 30-inch beds on September 21,1987. Sorghum and corn were planted on 30-inch beds on May 26, 1987. Planting rates for wheat were 64 lbs/A irrigated and 40 lbs/A dryland. Corn and sorghum were planted at rates to result in plant populations of 13,000 and 25,000 plants per acre, respectively.

Results and Discussion

Results obtained thus far are presented in Table 1. Since the experiment was not initiated until September 1987, most of the treatments were not in the proper sequence. Therefore, the only comparisons are between irrigated and dryland wheat and between corn and sorghum, both irrigated and dryland. The wheat plots were planted after 11 months of fallow, and the sorghum and corn were planted after 15 months of fallow. The preceding crop on the entire area was sorghum, harvested in October, 1986.

Corn and wheat yields were disappointing, particularly following irrigation. Yields of wheat were reduced by drought, wheat streak mosaic, and Russian wheat aphids. Dry soil conditions following corn planting prevented the formation of brace roots, resulting in lodging and eventual death of many plants. Spider mites caused early stress on the corn plants. Conversely, both irrigated and dryland grain sorghum tolerated the dry conditions very well, were not affected adversely by insects, and produced good yields.

1989 will be the first year with the various treatments in the proper sequence, and more definitive results are expected.

Table 1. Comparison of dryland and irrigated cropping systems, Garden City, KS.

Treatment	Wheat	Corn	Sorghum
		-Bu/A-	
Irrigated[1]	38	52	91
Dryland	30	36	63
Difference	8	16	28

[1]One in-season irrigation

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EFFECT OF PLANTING DATE, HYBRID, AND PLANT POPULATION ON THE YIELD OF DRYLAND GRAIN SORGHUM

Charles Norwood

Summary

Dryland grain sorghum was grown in separate studies in the wheat-sorghum-fallow (WSF) and continuous sorghum (SS) systems in 1987 and 1988. The objective was to determine if yields were affected by hybrid, date of planting, and plant population. In both systems, the yield of the latest maturing hybrid was reduced by late planting in 1987, but no differences occurred in 1988. In the SS system in 1987, higher plant populations resulted in more grain from both hybrids. In 1988, poor stands reduced yields to about half those of 1987, and further interpretations were not feasible.

Introduction

A study was designed to determine the optimum conditions for producing dryland grain sorghum in southwest Kansas. Date of planting, maturity of hybrid, and plant population were all expected to affect yield.

Procedures

Hybrids planted in both studies were Dekalb DK-42 and DK-46, having days to bloom of approximately 60 and 65, respectively. Planting dates in 1987 were June 4 and June 23; 1988 planting dates were June 4 and June 16. Target plant populations were 25,000 and 50,000 plants per acre for SS and a single population of 25,000 plants per acre for WSF. The plots were planted in 30-inch rows with a Buffalo slot planter.

Results and Discussion

Adverse conditions in both years resulted in plant populations less than desired. In 1987, dry topsoil on the first planting date reduced emergence, whereas rain followed by crusting resulted in reduced emergence for the second date. Dry soil conditions also reduced emergence in 1988, particularly for the second date.

In 1987, yields of DK-46 in both the WSF (Table 1) and SS (Table 2) systems were reduced by late planting. Rainfall delayed the second planting by about a week, thus, the longer season hybrid did not mature before frost. In the SS system, the higher plant population resulted in more grain from both dates in 1987. However, it should be noted that populations ranged from only 12,500 to 35,000 plants per acre in 1987, rather than the intended 25,000 and 50,000. Thus, yields may have been reduced by excessively low populations rather than enhanced by higher populations. Because of the drought and resulting erratic populations, no conclusions should be made about the 1988 SS data. WSF yields in 1988 were not reduced as much by the dry weather; however, there were no significant differences from either hybrid or date of planting.

Table 1. Effect of hybrid and date of planting on the yield of grain sorghum in a wheat-sorghum-fallow system, Garden City, KS.

	Date of planting			
Hybrid	6-4-87	6-23-87	6-4-88	6-16-88
		-Bu/A-		
Dekalb DK-42	68	58	44	50
Dekalb DK-46	65	49	41	47
lsd (0.05) Hybrid	7		ns	
Date	13		ns	

Table 2. Effect of date of planting, hybrid, and plant population on the yield of continuous dryland grain sorghum, Garden City, KS.

		Date of planting			
Hybrid		6-4-87	6-23-87	6-4-88	6-16-88
			-Bu/A-		
Dekalb DK-42	P1[1]	50	49	29	30
Dekalb DK-42	P2	58	55	25	24
Dekalb DK-46	P1	53	41	25	26
Dekalb DK-46	P2	67	50	24	24
lsd (0.05)	Date	11		ns	
	Hybrid	6		ns	
	Population	5		5	

[1] See text for plant populations

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SW Research-Extension Center
Kansas State University

USE OF COMMAND HERBICIDE FOR WEED CONTROL DURING FALLOW

Charles Norwood

Summary

Command is a herbicide developed by FMC Corporation for weed control in soybean. It was first labeled in 1986, and in 1988 was labeled for use during fallow in the wheat-fallow system. Recommended application times are between August 15 and October 31. Optimum weed control from Command alone results from late applications. Weed control is enhanced when atrazine is tank mixed with Command, particularly for early applications. Command is best suited for the control of volunteer wheat, but it also will give short-term suppression of common broadleaf weeds.

Introduction

A study was conducted to determine the effect of Command and Command + atrazine on control of volunteer wheat during fallow in a wheat-fallow system. Several applications were made to determine the optimum time of application.

Procedures

Command and atrazine were applied in the fall of 1987 to the stubble remaining from the wheat crop at the times and rates indicated in Table 1. The herbicides were applied with a tractor-mounted sprayer equipped with Teejet 110015 nozzles delivering 10 gpa at 30 psi and 4 mph. Control of volunteer wheat was evaluated on May 10, 1988.

Results and Discussion

Results are presented in Table 1. When Command was applied alone, control of volunteer wheat increased with later applications. Less than half of the volunteer wheat was controlled with an early August application, whereas over 90% was controlled with an early November application. Mixing atrazine with Command improved control over that obtained with Command alone, with the most improvement occurring on the earlier application dates. Conversely, compared to atrazine alone, Command + atrazine improved control more on the later dates.

Applications of Command result in both preemergent and postemergent activity, meaning that all of the volunteer wheat does not have to be emerged prior to application. Command will cause emerged volunteer wheat to die slowly, so it may not be killed completely before dormancy. The wheat then will die during the winter; regrowth has not been observed the following spring.

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Command is most effective on volunteer wheat, and it also may suppress some broadleaf weeds and grasses the following spring. However, it should not be relied on for long-term control. The addition of atrazine enhances residual control.

Table 1. Effect of Command and atrazine on the control of volunteer wheat during fallow as affected by date of application, Garden City, KS, 1987.

Treatment	Rate(lb/A)	Date applied			
		8/3	9/2	10/1	11/3
		-% volunteer control-			
Command	0.75	45	60	80	91
Command + Atrazine	0.50 + 0.50	96	88	92	100
Atrazine	0.50	96	90	70	92
		lsd(.10)	Rate 10		
			Date 10		

Rated 5/10/88

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SW Research-Extension Center
Kansas State University

EFFECT OF COMPOSTED MANURE AND NITROGEN FERTILIZER ON YIELD OF DRYLAND WINTER WHEAT

Alan Schlegel

Summary

In 1987, neither compost nor N fertilizer affected grain yield. In 1988, N increased grain yield and protein content, but compost had no effect.

Introduction

The objectives of this study are to determine the effects of composted manure from a beef feedlot on grain yield and protein content of dryland winter wheat.

Procedures

Dryland winter wheat was grown in a reduced tillage wheat-fallow rotation. The experimental design was a complete factorial of compost (0, 900, 1800, and 3600 lb/a) and nitrogen fertilizer (0, 22,44, and 66 lb N/a). Treatments were applied to the cropped area each year prior to wheat seeding. Winter wheat (TAM 107) was seeded at 40 lb/a on 9/27/86 and 9/11/87. Rainfall from planting to harvest was 14.79 inches in 1987 and 10.35 inches in 1988. All plots were machine harvested (6/28/87 and 6/23/88), and grain yield was adjusted to 12.5% moisture.

Results

Grain yield was not affected by compost or N fertilizer applications in 1987 (Table 1). Grain yield and protein increased with increased rates of N fertilizer in 1988 but were not affected by compost additions.

The project will be continued to determine the effect of repeated compost and N fertilizer applications on wheat yield and grain protein.

Table 1. Effect of compost and N fertilizer applications on grain yield of dryland winter wheat, Tribune, KS. 1987-1988.

Compost	Nitrogen rate	Grain yield 1987	Grain yield 1988	Grain protein
---------lb/a---------		------bu/a------		%
0	0	36.7	36.8	11.7
	22	36.0	43.3	12.0
	44	29.5	40.7	12.5
	66	36.5	45.6	13.5
900	0	36.2	37.4	11.5
	22	35.1	40.9	12.5
	44	37.8	43.7	13.5
	66	35.4	44.9	14.4
1800	0	30.4	37.7	11.2
	22	36.6	42.4	12.1
	44	35.6	47.1	12.8
	66	34.8	45.9	13.3
3600	0	36.3	38.1	11.8
	22	35.2	41.3	12.4
	44	36.4	43.4	12.9
	66	33.9	45.6	13.4
ANOVA				
Compost		ns	ns	ns
Nitrogen		ns	**	**
Compost*Nitrogen		ns	ns	ns
MEANS				
Compost (lb/a)	0	34.7a	41.6a	12.4ab
	900	36.1a	41.7a	12.9a
	1800	34.3a	43.3a	12.3b
	3600	35.5a	42.1a	12.6ab
$LSD_{.05}$		3.8	2.8	0.5
Nitrogen (lb/a)	0	34.9a	37.5b	11.6c
	22	35.7a	42.0a	12.3bc
	44	34.8a	43.7a	12.9b
	66	35.1a	45.5a	13.6a
$LSD_{.05}$		3.8	4.2	0.7

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SUMMARY OF CROP PERFORMANCE TESTS

Dwight G. Mosier, Kevin C. Dhuyvetter, and Merle Witt

Crop performance tests are conducted annually by Kansas State University Experiment Station researchers across the state to provide current information on hybrid/variety development. The number of entries entered into these tests are generally quite large and are published annually in performance test reports for each crop, which are available at your county extension office.

The following tables are brief listings by crop of the performance test varieties and/or hybrids that have been tested for the past three years in western Kansas. The 3-year average yields are ranked from highest to lowest for each crop and broken down into three yield groups: top, middle, and bottom. Additionally they have been indexed, so that each individual variety and/or hybrid can be compared to the test average on a percentage basis. This index provides producers, consultants, and industry personnel with a quick reference as to where each crop variety and/or hybrid ranked in relation to the test average.

The grain sorghum tables include a column showing the cost/bag (excluding any discounts) for each hybrid in 1988. It can be seen that there is little or no correlation between yields and the cost/bag.

Table 1. Thomas County Early Hybrid Corn

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
Asgrow/os Gold	2545	251	235	106%	232	106%
Horizon	717	260	236	107%	231	105%
Wilson	1700	254	235	106%	231	105%
Ohlde	230	247	230	104%	231	105%
Agripro	AP510	245	227	103%	230	105%
Ohlde	224	241	223	101%	228	104%
Golden Acres	T-E 6988	239	228	103%	227	103%
Lynks	LX4235	216	206	93%	211	96%
Bo-Jac	381	203	207	94%	210	95%
Golden Acres	T-E 6930	210	211	96%	205	93%
Nebraska	611	211	209	94%	204	93%
Nebraska	715	209	207	94%	200	91%
	Test Average	232	221	100%	220	100%

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Table 2. Thomas County Standard Corn

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
Cargill	7990	219	220	107%	222	105%
Bo-Jac	603	222	218	106%	221	105%
Bo-Jac	602	231	217	105%	220	104%
Garst	8388	229	217	105%	219	104%
Northrup-King	PX9540	225	215	104%	219	104%
Lynks	LX4355	221	214	103%	218	104%
Cargill	SX352	221	215	104%	217	103%
Asgrow/Os Gold	RX788	222	208	101%	216	103%
Triumph	1595	224	213	103%	216	103%
Horizon	871	208	212	103%	215	102%
Golden Harvest	H-2572	219	211	102%	215	102%
Hoegemeyer	SX2680	220	207	100%	214	101%
Ohlde	230	216	209	101%	212	101%
Wilson	2100	230	212	102%	212	101%
Wilson	2300	223	207	100%	211	100%
Horizon	5117	215	212	102%	211	100%
Agripro	AP670	212	206	100%	211	100%
Growers	GSC 2216	198	199	96%	207	98%
Growers	GSC 2212	209	204	99%	204	97%
Growers	GSC 2333	186	193	93%	204	97%
Garrison	SG 8215	172	188	91%	200	95%
Growers	GSC 2355	199	192	93%	195	93%
Nebraska	611	194	194	94%	193	91%
Nebraska	715	180	181	87%	183	87%
	Test Average	212	207	100%	211	100%

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Table 3. Finney County Corn

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
Garst	8345	207	189	105%	197	107%
Horizon	871	213	187	104%	196	106%
Golden Harvest	H-2601	206	184	102%	195	106%
Jacques	7900	212	185	102%	193	105%
Horizon	5117	205	185	102%	192	104%
Seedtec	WAC 920D	199	178	98%	191	104%
Golden Harvest	H-2572	219	189	105%	191	103%
Casterline	C1243	201	184	102%	190	103%
Golden Acres	T-E 6988	201	184	102%	190	103%
Bo-Jac	603	202	177	98%	190	103%
Triumph	1580	196	177	98%	189	103%
Growers	GSC 2212	208	186	103%	187	102%
Golden Harvest	H-2604	210	180	100%	187	101%
Casterline	C1233A	191	179	99%	187	101%
Bo-Jac	602	204	186	103%	187	101%
Growers	GSC 2216	203	177	98%	186	101%
Casterline	C1247	206	178	98%	185	100%
Agripro	AP820	198	179	99%	184	100%
Ohlde	230	210	191	106%	184	100%
Agripro	AP670	201	180	100%	183	99%
Triumph	1595	205	177	98%	182	99%
S-Brand	SS63B	199	182	101%	182	99%
Golden Acres	T-E 6996	203	182	101%	181	98%
Cargill	7990	218	200	111%	181	98%
Garst	8344	203	177	98%	180	98%
Nebraska	611	195	170	94%	180	98%
Nebraska	715	204	184	102%	179	97%
Growers	GSC 2333	199	170	94%	177	96%
Garrison	SG 8215	178	168	93%	174	94%
Growers	GSC 2355	198	174	97%	170	92%
Wilson	2300	195	169	94%	167	91%
Casterline	C1241	191	167	93%	161	87%
	Test Average	203	180	100%	184	100%

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Table 4. Greeley County Standard Corn

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
Cargill	7990	235	207	111%	207	109%
Horizon	871	227	201	108%	201	106%
Growers	GSC 2216	230	198	106%	199	105%
Growers	GSC 2212	203	187	100%	197	104%
Triumph	1595	214	193	103%	196	103%
Northrup-King	PX9540	218	195	105%	196	103%
Cargill	SX352	202	191	102%	196	103%
Golden Acres	T-E 6994	220	194	104%	195	102%
Growers	GSC 2355	212	187	100%	192	101%
Seedtec	WAC 915	216	187	100%	190	100%
Bo-Jac	603	208	185	99%	190	100%
Garrison	SG 8215	195	185	99%	189	99%
Bo-Jac	602	193	186	99%	189	99%
Agripro	AP670	203	184	98%	187	98%
Golden Acres	T-E 6996	183	171	92%	183	96%
Growers	GSC 2333	170	172	92%	177	93%
Nebraska	715	183	170	91%	171	90%
Nebraska	611	206	169	90%	171	90%
	Test Average	207	187	100%	190	100%

Table 5. Thomas County Fallow Grain Sorghum

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.	1988 Cost/bag
Oro	G Xtra	133	125	116%	124	112%	$39.90
Golden Acres	T-E Y-60	131	124	116%	124	112%	$38.50
Agripro	AP965G	128	120	112%	120	108%	$42.50
Cargill	70	101	114	106%	119	108%	$39.00
Garrison	SG 922	114	113	105%	118	107%	$37.50
Seedtec	ST-686	110	112	104%	114	103%	$38.50
Triumph	TR 60-G	114	109	102%	111	101%	$40.00
Funk's	G-550	112	110	103%	111	100%	$36.90
Cargill	40	110	99	92%	105	95%	$39.00
Casterline	SR 313 Plus	89	94	88%	100	90%	$38.00
Casterline	SR 305	100	86	80%	95	86%	$38.00
Triumph	TR 50yG	86	83	77%	88	79%	$40.00
	Test Average	111	107	100%	111	100%	$38.98

Table 6. Thomas County Irrigated Grain Sorghum

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.	1988 Cost/bag
Oro	G Xtra	184	182	108%	183	110%	$39.90
Asgrow	GS712	180	178	106%	181	108%	$38.00
Triumph	Two 80-D	182	178	106%	180	108%	$38.00
Seedtec	ST-D701G	180	178	106%	179	108%	$38.50
Seedtec	ST-686	191	183	109%	178	107%	$38.50
Golden Acres	T-E Y-75	180	176	105%	175	105%	$38.50
Conti	Top Hand II	176	172	103%	175	105%	$39.00
Conti	Rustler	176	176	105%	174	105%	$39.00
Seedtec	ST-710DR	171	175	104%	172	103%	$36.50
Garrison	SG 922	172	172	102%	172	103%	$37.50
Casterline	SR 323 Plus	175	178	106%	171	103%	$38.00
Cargill	DR 1125	174	171	102%	170	102%	$35.00
Northrup-King	NK 2656	174	174	104%	170	102%	$40.00
Golden Acres	T-E Dinero	176	172	102%	169	101%	$36.50
Cargill	4462	174	170	102%	168	101%	$35.00
Agripro	AP965G	168	165	99%	167	100%	$42.50
Growers	GSA 1212	167	166	99%	167	100%	$39.75
Triumph	Two 70-D	161	163	97%	166	100%	$38.00
Asgrow	Topaz	176	165	99%	162	97%	$38.00
Funk's	G-550	165	161	96%	155	93%	$36.90
Triumph	TR 74CR	161	154	92%	155	93%	$40.00
Cargill	70	162	155	92%	155	93%	$39.00
NC+	165	154	144	86%	144	86%	$40.00
Cargill	1022	145	143	85%	143	86%	$39.00
Cargill	40	146	138	82%	137	82%	$39.00
	Test Average	171	167	100%	167	100%	$38.40

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Table 7. Finney County Fallow Grain Sorghum

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.	1988 Cost/bag
Cargill	70	55	54	122%	55	118%	$39.00
Seedtec	ST-D701G	49	55	124%	53	114%	$38.50
Oro	G Xtra	48	56	126%	52	112%	$39.90
Triumph	Two 70-D	44	49	110%	52	112%	$38.00
Triumph	Two 64yG	49	46	105%	51	110%	$38.00
Seedtec	ST-686	47	45	102%	48	104%	$38.50
Cargill	5572	39	46	105%	48	103%	$39.00
Funk's	G-550	50	42	94%	46	99%	$36.90
Casterline	SR 313	45	41	92%	44	95%	$38.00
Golden Acres	T-E Y-60	48	41	92%	42	91%	$38.50
Northrup-King	NK 2030	42	37	84%	41	88%	$37.00
Cargill	40	40	39	89%	41	88%	$39.00
Casterline	SR 305	38	32	73%	38	83%	$38.00
Casterline	SR 313 Plus	40	36	81%	38	82%	$38.00
	Test Average	45	44	100%	46	100%	$38.31

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Table 8. Finney County Irrigated Grain Sorghum

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.	1988 Cost/bag
Northrup-King	NK 2656	145	136	112%	137	108%	$40.00
Golden Harvest	H-514B	121	128	106%	136	107%	$40.00
Cargill	6670	124	129	106%	135	106%	$39.00
Casterline	325	123	130	107%	134	106%	$38.00
Garrison	SG 932	127	126	104%	134	105%	$37.50
Casterline	SR 323 Plus	146	130	107%	133	105%	$38.00
Northrup-King	S 9750	130	129	107%	133	105%	$40.00
Cargill	5572	133	133	110%	132	104%	$39.00
Triumph	Two 80-D	130	124	102%	132	104%	$38.00
Garst	5319	121	126	104%	132	104%	$38.00
Golden Acres	T-E Y-75	143	128	105%	131	104%	$38.50
Asgrow	GS712	132	126	104%	131	104%	$38.00
Oro	G Xtra	126	126	104%	131	103%	$39.90
Garst	5521	119	125	103%	130	103%	$38.00
Conti	Rustler	127	123	101%	130	102%	$39.00
Agripro	AP965G	127	124	102%	129	102%	$42.50
Asgrow	Topaz	121	127	105%	129	101%	$38.00
Seedtec	ST-D701G	120	121	100%	128	101%	$38.50
Golden Acres	T-E Dinero	120	122	101%	128	101%	$36.50
Horizon	76G	117	125	103%	128	101%	$37.50
Seedtec	ST-710DR	127	124	102%	127	100%	$36.50
Cargill	DR 1125	122	119	98%	125	98%	$35.00
Horizon	103G	122	121	100%	125	98%	$37.50
Garrison	SG 922	111	120	99%	125	98%	$37.50
Triumph	Two 64yG	109	115	95%	121	95%	$38.00
Golden Harvest	H-510B	106	113	93%	121	95%	$40.00
Cargill	70	101	113	93%	120	95%	$39.00
Conti	Top Hand II	114	115	95%	120	95%	$39.00
Growers	GSC 1299	106	109	90%	118	93%	$39.75
Triumph	TR 74CR	113	108	89%	116	92%	$40.00
Horizon	101G	104	110	90%	116	92%	$37.50
Growers	GSA 1310A	99	109	90%	116	92%	$39.75
Cargill	40	97	89	74%	102	80%	$39.00
	Test Average	121	121	100%	127	100%	$38.56

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Table 9. Greeley County Irrigated Grain Sorghum

Brand	Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.	1988 Cost/bag
Seedtec	ST-D701G	166	155	104%	158	106%	$38.50
Asgrow	GS712	158	156	104%	158	106%	$38.00
Oro	G Xtra	150	147	99%	156	105%	$39.90
Triumph	Two 80-D	162	155	104%	156	104%	$38.00
Seedtec	ST-686	160	160	107%	155	104%	$38.50
Golden Acres	T-E Y-75	156	158	106%	155	104%	$38.50
Seedtec	ST-710DR	155	156	105%	155	104%	$36.50
Conti	Rustler	159	155	104%	154	103%	$39.00
Horizon	76G	154	152	102%	152	102%	$37.50
Conti	Top Hand II	146	147	99%	151	101%	$39.00
Cargill	4462	166	157	105%	150	100%	$35.00
Triumph	Two 70-D	145	149	100%	150	100%	$38.00
Asgrow	Topaz	151	142	95%	149	100%	$38.00
Agripro	AP965G	147	152	102%	148	99%	$42.50
Growers	GSC 1299	159	147	98%	147	99%	$39.75
Cargill	5572	146	144	97%	147	98%	$39.00
Garrison	SG 922	144	143	96%	146	98%	$37.50
Golden Acres	T-E Dinero	147	146	98%	145	97%	$36.50
Cargill	70	148	145	97%	141	94%	$39.00
Funk's	G-550	163	142	95%	138	92%	$36.90
Cargill	40	150	130	87%	128	86%	$39.00
	Test Average	154	149	100%	150	100%	$38.31

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Table 10. Thomas County Dryland Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 107	30	54	118%	52	120%
----	Century	31	50	109%	48	111%
----	TAM 108	26	46	99%	47	108%
Bounty	BH122	30	47	103%	46	107%
Agripro	Victory	40	49	107%	45	104%
Quantam	562	32	47	103%	45	104%
----	Larned	32	48	105%	44	102%
----	Norkan	30	47	103%	44	101%
----	Redland	29	45	97%	43	100%
----	Colt	26	45	97%	43	100%
Agripro	Thunderbird	35	45	98%	42	98%
----	Newton	27	44	95%	42	97%
----	Arkan	28	45	98%	41	95%
----	Centura	31	46	100%	41	94%
----	Scout 66	33	44	95%	40	93%
DeLange	7837	27	42	91%	40	92%
----	Dodge	32	42	92%	37	86%
----	Siouxland	29	41	90%	37	86%
	Test Average	30	46	100%	43	100%

Table 11. Thomas County Irrigated Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 107	68	69	111%	67	115%
----	Colt	60	67	108%	64	110%
Bounty	BH122	55	64	103%	62	105%
----	TAM 108	56	62	99%	61	104%
Quantam	562	59	62	99%	60	103%
----	Century	56	61	99%	60	102%
Agripro	Victory	65	66	106%	59	101%
Agripro	Thunderbird	58	63	102%	59	101%
----	Norkan	54	63	101%	57	98%
----	Arkan	52	58	94%	55	94%
----	Newton	55	58	94%	54	92%
----	Dodge	59	59	94%	52	89%
----	Siouxland	53	56	90%	50	86%
	Test Average	58	62	100%	58	100%

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Table 12. Finney County Dryland Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 107	33	31	127%	38	113%
Agripro	Mustang	20	26	108%	36	108%
----	Larned	18	26	106%	35	104%
----	TAM 108	20	25	102%	34	102%
----	Newton	22	24	98%	33	99%
----	Scout 66	20	25	102%	33	98%
----	Chisholm	20	22	91%	32	97%
----	TAM 105	21	23	96%	32	96%
----	Arkan	10	17	71%	29	86%
	Test Average	20	24	100%	33	100%

Table 13. Finney County Irrigated Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 107	93	71	130%	78	120%
Bounty	BH122	79	61	112%	73	112%
----	TAM 105	74	63	115%	69	106%
----	Chisholm	69	59	108%	68	104%
----	Century	74	57	103%	67	104%
Agripro	Thunderbird	69	56	102%	65	101%
Agripro	Victory	66	53	97%	64	99%
Agripro	Mustang	64	50	92%	64	98%
----	Newton	69	53	96%	63	97%
----	TAM 108	57	49	90%	62	96%
Agripro	Stallion	71	53	96%	61	95%
----	Norkan	68	51	92%	61	94%
----	Arkan	62	46	84%	57	87%
----	Dodge	55	45	82%	56	86%
	Test Average	69	55	100%	65	100%

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Table 14. Greeley County Dryland Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 107	49	46	122%	42	120%
Quantam	562	43	42	113%	39	113%
----	TAM 105	42	41	110%	39	113%
----	Century	40	42	112%	39	112%
----	TAM 108	40	39	105%	37	107%
----	Newton	44	40	106%	36	104%
Agripro	Mustang	43	38	101%	35	102%
----	Redland	42	39	105%	35	101%
----	Sandy	39	38	101%	35	100%
----	Siouxland	37	37	98%	35	100%
----	Larned	40	38	102%	34	99%
----	Colt	38	35	94%	34	99%
Agripro	Victory	40	36	96%	34	97%
----	Norkan	37	35	93%	32	92%
----	Scout 66	36	36	96%	32	92%
Agripro	Thunderbird	37	34	90%	31	89%
----	Dodge	33	32	85%	28	82%
----	Arkan	26	27	71%	27	77%
	Test Average	39	37	100%	35	100%

Table 15. Greeley County Irrigated Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 107	55	66	119%	69	118%
Agripro	Victory	57	55	99%	62	105%
----	TAM 105	50	62	112%	61	105%
Agripro	Mustang	51	57	103%	60	103%
Agripro	Stallion	47	54	97%	60	102%
----	Colt	48	54	97%	57	97%
----	Newton	46	55	98%	56	96%
----	TAM 108	44	57	103%	55	94%
----	Arkan	44	47	84%	53	90%
----	Siouxland	38	48	87%	52	89%
	Test Average	48	55	100%	59	100%

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Table 16. Stafford County Dryland Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 108	33	45	120%	50	117%
Bounty	BH122	29	40	107%	50	116%
----	Centura	34	41	110%	49	114%
----	Century	33	39	106%	47	110%
----	Larned	40	43	115%	46	108%
----	Sandy	30	40	108%	45	106%
----	Chisholm	25	39	106%	45	105%
Agripro	Victory	37	41	110%	45	104%
----	TAM 107	46	46	124%	44	103%
----	Scout 66	36	40	107%	43	101%
Agripro	Thunderbird	31	43	116%	43	101%
----	Vona	24	30	80%	43	101%
----	Siouxland	35	37	100%	42	97%
Agripro	Mustang	28	32	85%	41	96%
DeLange	7837	23	30	81%	41	96%
----	TAM 105	34	38	103%	41	96%
----	Newton	33	35	95%	40	93%
----	Norkan	26	31	84%	38	89%
----	Dodge	21	28	74%	37	85%
Agripro	Stallion	24	34	91%	36	83%
----	Arkan	22	29	78%	34	78%
	Test Average	31	37	100%	43	100%

Table 17. Stafford County Irrigated Wheat

Brand	Variety or Hybrid	1988	2-Yr Avg.	% of Avg.	3-Yr Avg.	% of Avg.
----	TAM 108	74	60	128%	74	130%
Agripro	Victory	72	53	113%	66	116%
----	Norkan	65	53	113%	65	113%
Agripro	Thunderbird	66	54	114%	64	111%
Agripro	Stallion	64	51	108%	62	109%
----	Arkan	64	49	104%	59	104%
----	Newton	65	47	99%	58	102%
Agripro	Mustang	61	44	93%	57	100%
----	Century	53	47	99%	55	95%
----	Dodge	58	41	86%	52	90%
Bounty	BH122	36	40	85%	50	87%
----	Chisholm	33	41	87%	47	82%
----	TAM 105	33	39	83%	46	81%
----	TAM 107	43	41	86%	46	80%
	Test Average	56	47	100%	57	100%

CROP PERFORMANCE TESTS - HIGH YIELDERS

Merle Witt and Dwight G. Mosier

Crop performance tests are conducted annually by Kansas State University researchers across the state to provide current information on hybrid/variety development. The number of entries in these tests is generally quite large, so a brief list of the "High 10" or "High 5" in yield values during recent tests at several western Kansas locations have been compiled to give producers, consultants, and industry personnel a quick reference as to how their product ranked in performance. More complete information on these and other crops is published in performance test reports, which are available at your county extension office.

ALFALFAS

Garden City

High 5 1985-87	Tons/A
Great Plains Res-Cimarron	9.90
Pioneer 555	9.83
W.L. - WL321	9.75
Dekalb-Pfizer-Advantage	9.73
Agripro - Arrow	9.71

High 5 1986-87	
Pioneer 555	10.00
Great Plains Res-Cimarron	9.99
Agripro - Arrow	9.90
W.L. - WL321	9.85
Dekalb-Pfizer-Advantage	9.84

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CORN HYBRIDS

Garden City

High 10 1986-88

High 10 1986-88	Bu/A (% Lodged)
Garst 8345	197(0)
Horizon 871	196(0)
Golden Harvest H-2601	195(0)
Jacques 7900	193(0)
SeedTec WAC 920D	192(0)
Horizon 5117	192(1)
Golden Harvest H-2572	191(0)
Bo-Jac 603	190(0)
Casterline C1243	190(0)
Golden Acres T-E 6988	190(2)

High 5 1987-88

High 5 1987-88	Bu/A (% Lodged)
Cargill 7900	200(0)
Ohlde 230	191(0)
Garst 8345	189(0)
Golden Harvest H-2572	189(0)
Hoegemeyer SX2680	189(0)

Colby

High 10 1986-88

High 10 1986-88	Bu/A (% Lodged)
Cargill 7990	222(3)
Bo-Jac 603	221(1)
Bo-Jac 602	220(2)
Garst 8388	219(T)
Northrup-King PX9540	219(1)
Lynks LX4355	218(1)
Cargill SX352	217(T)
Asgrow/Osgold RX788	216(1)
Triumph 1595	216(1)
Golden Harvest H-2572	215(1)
Horizon 871	215(1)

High 5 1987-88

High 5 1987-88	Bu/A (% Lodged)
Cargill 7990	220(3)
S-Brand 5563B	220(1)
Dahlgren DC-545	219(1)
Bo-Jac 603	218(1)
S-Brand 5562A	218(2)
S-Brand 5562B	218(2)

Tribune

High 10 1986-88

High 10 1986-88	Bu/A (% Lodged)
Cargill 7990	206 (8
Horizon 871	201(11
Growers GSC 2216	199 (7
Growers GSC 2212	197(10
Cargill SX352	196 (8
Northrup-King PX9540	196 (9
Triumph 1595	196 (6
Golden Acres T-E6994	195(15
Growers GSC2355	192 (7
SeedTec WAC 915	191 (7

High 5 1987-88

High 5 1987-88	Bu/A (% Lodged)
Cargill 7990	207(2)
Horizon 871	201(11)
Wilson 2300	200(3)
S-Brand 5563B	197(6)
Growers GSC2216	197(7)

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GRAIN SORGHUM - IRRIGATED

Garden City

High 10 1986-88 Bu/A (Days to Bloom)

Northrup-King NK2656	137(74)
Golden Harvest H-514B	136(77)
Cargill 6670	135(79)
Casterline 325	134(78)
Garrison SG932	134(78)
Casterline SR323 Plus	133(77)
Northrup-King S9750	133(77)
155(71)	
Cargill 5572	132(75)
Golden Acres T-E Y-75	132(75)
Triumph Two 80-D	132(79)
Stauffer 59750	135(76)

High 5 1987-88

DeKalb-Pfizer DK-66	144(80)
Northrup-King NK2656	136(74)
Warner W-844-E	133(74)
Cargill 5572	133(78)
Casterline SR 323 Plus	130(75)

Tribune

High 10 1986-88 Bu/A (Days to Bloom)

Asgrow GS712	158(72)
SeedTec ST- D701G	158(71)
Oro G XTRA	156(74)
Triumph Two 80-D	156(73)
Golden Acres T-E Y-75	155(72)
SeedTec St-710DR	155(71)
SeedTec ST-686	
Conti Rustler	154(73)
Horizon 76G	152(72)
Conti Top Hand II	151(71)

High 5 1987-88

Garrison SG932	166(69)
SeedTec ST-686	159(71)
Cargill 6670	158(73)
Golden Acres T-E Y-75	158(72)
Cargill 4462	157(70)

Colby

High 10 1987-88

Oro G Xtra	183(69)
Asgrow GS 712	181(70)
SeedTec ST-D701G	179(69)
Triumph Two 80-D	179(69)
SeedTec ST-686	178(67)
Conti Top Hand II	175(67)
Conti Rustler	174(69)
Golden Acres T-E Y-75	174(68)
Garrison SG 922	172(68)
SeedTec St-710DR	172(68)

High 5 1986-87

Garrison SG932	187(68)
Asgrow Osage	183(70)
SeedTec ST-686	183(67)
Oro G Xtra	182(69)
Cargill 6670	180(70)

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GRAIN SORGHUMS - DRYLAND

Garden City

High 10 1986-88	Bu/A (days to bloom)
Cargill 70	55(76)
SeedTec ST-D701G	53(82)
Triumph Two 70-D	52(77)
Oro G XTRA	52(82)
Triumph Two 64yG	51(77)
SeedTec ST-686	48(78)
Cargill 5572	48(78)
Funk's G-550	46(70)
Casterline SR313	44(72)
Golden Acres T-E Y-60	42(70)

High 5 1987-88	
Oro G XTRA	56(82)
SeedTec ST-D701G	55(82)
Cargill 70	54(76)
Garst 5511	54(78)
Triumph II 70-D	49(77)

Colby

High 10 1986-88	Bu/A (days to bloom)
Golden Acres T-E Y-60	124(61)
Oro G XTRA	124(70)
Agripro AP965G	120(68)
Cargill 70	119(71)
Garrison SG922	118(69)
SeedTec ST-686	114(69)
Funk's G-550	111(61)
Triumph TR 60-G	111(67)
Cargill 40	105(64)
Casterline SR 313 Plus	99(63)

High 5 1987-88	
Oro G XTRA	125(70)
Golden Acres T-E Y-60	124(61)
Garrison SG932	123(71)
Golden Harvest H-501	122(69)
Agripro AP965G	120(68)

FORAGE SORGHUMS

Garden City

High 5 1986-88	Tons/A (Grain Bu/A)
Triumph Super Sile 20	33(76)
DeKalb FS-25E	32(74)
Golden Acres T-E Yieldmaker	30(78)
Casterline Silo Plus	28(51)
Sugar Drip	24(41)

High 5 1986-88	
Triumph Super Sile 20	36(103)
DeKalb FS-25E	34(88)
Golden Acres T-E Yieldmaker	32(99)
Casterline Silo Plus	29(82)
Sugar Drip	26(57)

SOYBEANS-IRRIGATED

Garden City

High 5 1986-88	Bu/A (Maturity Group)
Asgrow A44595	65(IV)
Ohlde 3431	64(III)
DeKalb Pfizer CX415	64(IV)
S-Brand S-67	63(III)
Sparks	62(IV)

High 5 1987-87	
Asgrow A4595	67(IV)
Asgrow A4393	64(III)
Spencer	64(IV)
Ohlde 4122	63(IV)
DeKalb Pfizer CX415	63(IV)

Colby

High 5 1986-88	Bu/A (Maturity Group)
DeKalb-Pfizer CX366	66(III)
S-Brand S-46F	65(II)
Golden Harvest H-1285	65(II)
Zane	65(III)
Ohlde 2193	64(II)

High 5 1987-87	
Ohlde 3431	67(III)
Golden Harvest H-1285	65(II)
S-Brand S-67	65(III)
Spencer	65(III)
Zane	64(III)

SUNFLOWERS (oilseed)

Garden City

High 5 1986-88	lbs/A (% Oil)
Triumph 565	1840(45.6)
Cargill SF100	1736(40.8)
SeedTec 317	1725(44.0)
Groagri Sungro 380A	1704(45.2)
Contiseed Hysun 354	1680(44.5)

High 5 1987-88	
Cargill SF100	1992(42.1)
Cargill SF187	1868(43.1)
Triumph 565	1838(46.4)
SeedTec 317	1788(45.5)
Contiseed Hysun 33	1785(41.9)

Colby

High 5 1986-88	lbs/A (% Oil)
Contiseed Hysun 354	2961(42.3)
Triumph 548	2863(42.4)
Triumph 565	2848(42.2)
Dahlgren D0855	2846(40.6)
Contiseed Hysun 33	2844(38.2)

High 5 1987-88	
Cargill SF100	3189(37.8)
Conti Hysun 354	3152(41.6)
Groagri Sungro 382	3058(39.1)
Cargill 208	3045(37.6)
Triumph 548	3019(42.5)

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WHEATS - DRYLAND

Garden City

High 5 (1985,86,88)	Bu/A
Tam 107	38
Mustang	36
Larned	34
Tam 108	33
Newton	33
Scout 66	33

High 5 (86,88)	Bu/A
Tam 107	31
Mustang	26
Bounty BH 122	26
Larned	25
Redland	25
Scout 66	25

Tribune

High 5 (86-88)	
Tam 107	42
Century	39
Quantum 562	39
Tam 105	39
Tam 108	37

High 5 (87-88)	
Tam 107	46
Century	42
Quantum 562	42
Abilene	41
Tam 105	41

Colby

High 5 (86-88)	
Tam 107	51
Century	48
Tam 108	47
Bounty BH122	46
Victory	45
Quantum 562	45

High 5 (86-87)	
Tam 107	54
Century	50
Abilene	49
Victory	49
DeLange 7846	49

WHEATS - IRRIGATED

Garden City

High 5 (86-88)	Bu/A
Tam 107	78
Bounty BH122	73
Tam 105	69
Chisholm	68
Century	67

High 5 (87-88)	Bu/A
Tam 107	71
Tam 200	70
Mesa	68
Tam 105	63
Abilene	62

Tribune

High 5 (85-88)	
Tam 107	70
Victory	62
Tam 105	61
Stallion	60
Mustang	60

High 5 (87-88)	
Tam 107	66
Tam 105	62
Mustang	57
Tam 108	57
Victory	55

Colby

High 5 (86-88)	
Tam 107	67
Colt	64
Bounty BH122	62
Tam 108	61
Quantum 562	60

High 5 (87-88)	
Mesa	76
Tam 107	69
Colt	67
Abilene	66
Victory	65

Southwest Kansas Research-Extension Center
Support Personnel

Jovita Baier, Secretary I
Ernie Butler, Animal Caretaker II
Lori Carter, Agricultural Technician
Don Childers, Automotive Mechanic I
Eugene Cozad, Automotive Mechanic II
Marvin Cronin, Jr., Agricultural Technician
Vicki Dye, Agricultural Lab Technician I
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David Frickel, Agricultural Technician
Blane Hergert, Agricultural Technician
Roberta Huddleston, Office Assistant III
Cathy Jackson, Animal Caretaker II
Leslie McGrew, Extension Secretary II
Dennis Mead, Farmer II
Joanna Meier, Office Assistant IV
Henry Melgosa, Farmer II
Ann Parks, Extension Office Assistant II
Ramon Servantez, Agricultural Lab Technican II
Monty Spangler, Farmer II
Margaret Steward, Agricultural Technician
Carl Warner, Farmer II
Bob Wilson, Agricultural Technician

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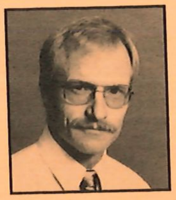
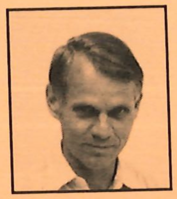
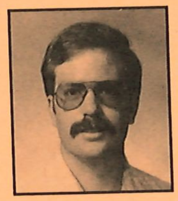


Dwight Mosier - Extension Agronomist. Dwight received his M.S. from Kansas State University and his Ph.D. from the University of Arkansas. He joined the staff in 1986. His extension program responsibilities include all aspects of soils and field crop production.

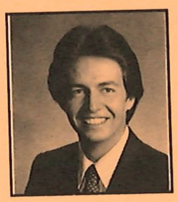


Charles Norwood - Agronomist - Dryland Soil Management. He has M.S. and Ph.D. degrees from Oklahoma State University. He joined the staff in 1972. Charles' primary research responsibilities include dryland soil and crop management, with emphasis on reduced and no-tillage cropping systems.

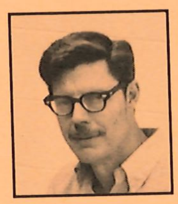
Alan Schlegel - Agronomist-in-Charge, Tribune. Alan received his M.S. and Ph.D. degrees at Purdue University. He joined the staff in 1986. His research involves fertilizer and water management in reduced tillage systems.



Phil Sloderbeck - Extension Entomologist. Phil received his M.S. from Purdue University and his Ph.D. from the University of Kentucky. He joined the staff in 1981. His extension emphasis is on insect pests of field crops.



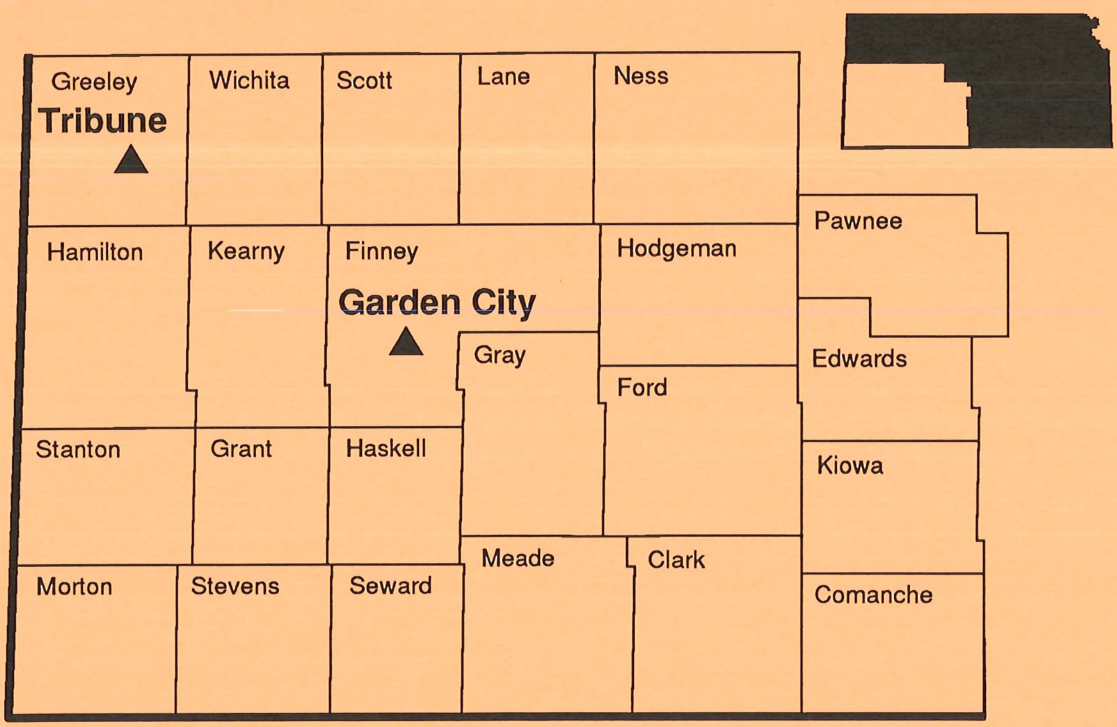
Bill Spurgeon - Agricultural Engineer. Bill received his M.S. from the University of Nebraska and his Ph.D. from Colorado State. He joined the staff in 1988. His research interests include surface irrigation, drip irrigation, and LEPA (Low Energy Precision Application) with center pivots.



Merle Witt - Agronomist - Crop Specialist. He received an M.S. at Kansas State University and joined the staff in 1969. He received his Ph.D. from the University of Nebraska in 1981. Merle's research has included varietal and cultural testing of established crops and potential crops for Southwest Kansas.

Carol Young - Extension Home Economist. Carol received her M.S. degree from Wichita State University. She joined the staff in 1982 after serving as County Extension Home Economist in Osage, Sumner, and Edwards counties. She is responsible for Home Economics program development in Southwest Kansas.

SERVICE AREA — SWK RESEARCH-EXTENSION CENTER



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Report of Progress 572 May 1989

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9

1989 AGRICULTURAL RESEARCH

NORTHWEST RESEARCH-EXTENSION CENTER

Report of Progress 576

Agricultural Experiment Station

Kansas State University, Manhattan

Walter R. Woods, Director

H Energy and NR
3-14-90

Attachment 9

RICHARD WHITE became Head of the Northwest Research-Extension Center in 1987 when the Colby Branch Experiment Station was merged with the Northwest Area Extension Office. He received his B.S. degree from Humboldt State University, M.S. from Texas Tech University, and Ph.D. degree from Utah State University. Before joining the Colby faculty, he worked for 11 years in Montana as a Research Plant Physiologist with the Agricultural Research Service.

REBA WHITE joined the Northwest Research-Extension Center staff as Associate Head and Area Director in 1988. She received her B.S. and M.S. degrees from Kansas State University and has 16 year's experience as County Extension Agent and County Extension Director.

JOHN LAWLESS received an M.S. degree from Washington State University in 1960 and joined the Colby staff that same year as Crops Research Scientist. His research has included both varietal and cultural testing and has involved all crops grown in northwestern Kansas. Current research emphasis is on evaluating reduced tillage methods in wheat production and on quality improvement of wheat seed.

FRANK SCHWULST received M.S. and Ph.D. degrees in Animal Science from the University of Nebraska. He spent six years at American University of Beirut before joining the Colby Experiment Station faculty in 1974. Research interests include animal breeding, ewe flock management, feeding rations for fattening lambs, and pasture crops.

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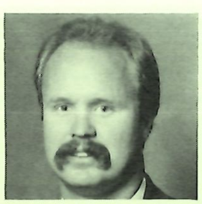

FREDDIE LAMM has been Research Agricultural Engineer at the Colby Branch Experiment Station since 1979. He received his B.S. and M.S. in Agricultural Engineering from the University of Missouri-Columbia in 1978 and 1979, respectively. His primary research concerns are water conservation and management for both irrigated and dryland conditions.

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1989 REPORT OF AGRICULTURAL RESEARCH

Northwest Research-Extension Center,
Kansas State University

CONTENTS

Contribution No. 89-531-S

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Interpreting Results and Statistical Analyses

H. D. Sunderman

It is virtually impossible to conduct perfect tests because soil and other environmental factors vary from location to location within a field. So, small differences in responses measured among treatments may have no real meaning. To help interpret data, we applied a statistical technique called analysis of variance wherever possible. Such an analysis requires the random placement of individual treatments within a test site and then repeating them several times (replication) to obtain a measurement of site variability.

Results of the analyses are reported in terms of the least significant differences (LSD). If two means differ by more than, for example, $LSD_{0.05}$, then such a difference would be due to chance variation only 5 percent of the time. So, it's 95% probable that the difference was due to treatment. On the other hand, if the two means do not differ by more than the $LSD_{0.05}$, it's only 5 percent probable that the difference is due to treatment and 95 percent probable that it's due to chance variability. If means do not differ by as much as the LSD, then little confidence can be placed in the importance of varietal or treatment differences.

Research demands a high level of precision for drawing conclusions and, thus, $LSD_{0.05}$ is used. On the other hand, growers may be willing to accept more risk and can sometimes profitably accept LSD values based on lower probabilities. In the case of a $LSD_{0.50}$, there's a 50-50 chance that a difference is real or a 50-50 chance it's not. As the consequences of making the wrong conclusion become more severe, growers should require higher and higher precision before acting on experimental results.

Planting Suggestions

J. R. Lawless and M. E. Mikesell

Planting date and rate suggestions for northwestern Kansas are included in Table 1. Variations in area and seasonal conditions and differences in seed sizes among varieties or seedlots make exact recommendations impossible. The range given for date and rate recommendations allows for row crops like corn, grain sorghum, and soybeans, for which relatively low plant populations are used and wide variations in seed sizes exist. To assure proper within-row seed spacing, special calibrations based on desired plant spacing, row width, and percentages of plants that germinate and emerge are needed. Additional guides for determining proper seed spacings for corn, sorghum, and soybeans are given in Kansas State University Cooperative Extension Service publication L-142 Revised, "Planting Crops in Kansas," March 1982.

Table 1. Suggested planting dates and rates for crops in northwestern Kansas.

Crop	Planting dates	Planting rate Dryland	Planting rate Irrigated
		---lbs./acre----	
Wheat	9/10-9/20	30-50	60-90
Winter barley	9/10-9/20	40-50	75-96
Spring barley	2/25-3/15	60-84	75-96
Spring oats	3/5-3/20	48-64	48-64
Alfalfa - fall	8/10-8/30	8-10	10-15
- spring	4/25-6/1	8-10	10-15
Sudangrass - drill	5/15-7/1	10-15	30
- row	5/15-7/1	2-4	--
		1000 plants/acre	
Corn	5/1-5/20	10-15[1]	20-28[2]
Sorghum	5/15-6/5	24	100
Soybeans	5/10-6/1	--	140
Sunflowers	5/7-6/20	12-15	15-25

1 Recommended only for bottomland soils.

2 Rates above 24,000 are for early-maturing hybrids only.

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1988 Climatological Data

H. D. Sunderman

The Kansas Agricultural Experiment Station has provided a weather observer in Colby for the National Oceanic and Atmospheric Administration (NOAA) since 1957. However, weather records collected at Colby since 1900 are on file and available for public use.

The "official" weather station is currently located at an elevation of 3170 feet, latitude 39° 29′ north, and longitude 101° 04′ west. In addition to the NOAA station, an automated weather station collects more detailed hourly and daily data on numerous climatic features. These data are stored on computer disk in the NWREC soils project office and are also available to the public.

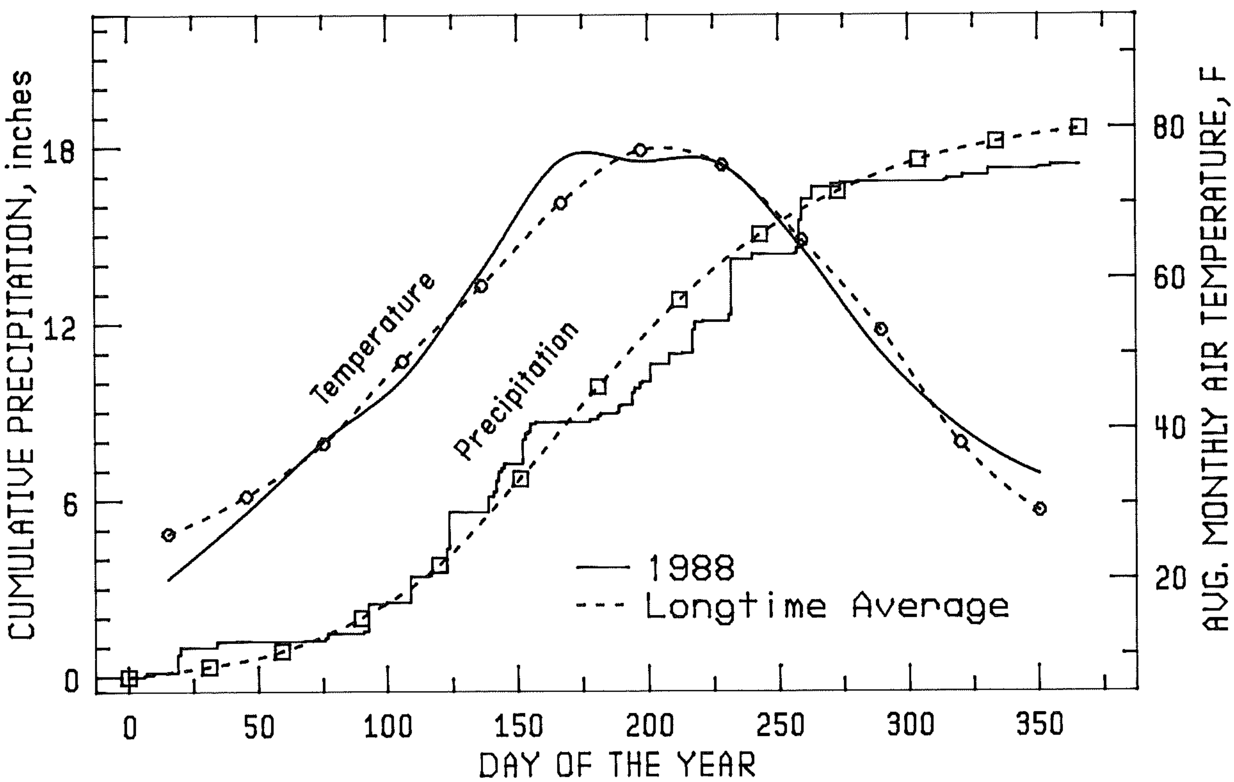
The 1988 and longtime averages for air temperature, wind velocity, evaporation, precipitation, and snowfall are shown by month in Table 1. Daily precipitation amounts and monthly average air temperatures are shown graphically in Figure 1. Table 2 contains a summary of precipitation occurrences and amounts during 1988. A few features not detailed in other tables are shown in Table 3. Heating and cooling degree days (Table 4), probabilities for precipitation (Table 5), and probabilities for freeze dates and lengths of freeze-free periods (Table 6) are based on weather data collected during the period from 1951 to 1980 and summarized by NOAA.

The calendar year was typical in numerous respects. Records were broken. We experienced periods of prolonged drought and rain, discomfortingly low and high temperatures, and windy conditions just as during any "average" year in northwestern Kansas. In a nutshell, producers' abilities to respond were rigorously tested and crops were adversely influenced by the weather--as usual.

Headlines throughout the country focused on a deepening drought and record-breaking high temperatures. Rivers were at all time low levels. Crops perished. Livestock had to be sold because of feed and water shortages.

But, at Colby, the weather pattern was fairly normal in many respects. Cumulative precipitation for the calendar year was about as near the normal curve as one could expect (Fig. 1). Dry periods of varying length began in late January, early June, and late September. Such variation is characteristic of the area's climate and a major reason for the prevailing cropping systems.

Fig. 1. Graphical comparison of 1988 precipitation amounts and average monthly air temperatures with longtime averages at the NWREC.



For the year, precipitation was recorded during 106 days to total 17.40 inches, 1.22 below average. But only two events exceeded an inch, and only 10 were greater than 0.5 inch. There were 87 that were equal to or less than 0.25 inch.

The dry period in January was particularly troublesome because of the dry seeding conditions the previous fall. As a result, seeds had failed to germinate or developed into poorly rooted seedlings and skippy stands. Windy conditions caused severe wind erosion in many fields, and emergency tillage was sometimes necessary. Below-average precipitation amounts during the last 3 months of the year created concerns that history was too quickly repeating itself.

The effect of the dry period in June was magnified by a flurry of 100-degree days. Interrupted only by a 99 recorded for the 24th, there were 9 100-degree days recorded from the 18th to the 26th. Had that 99 been a 100, the record for most consecutive 100-degree days recorded at Colby also would have been broken. Only 5 other 100-degree days were recorded during the rest of the year--3 in July and 2 in August.

Wheat was in the late-milk to grain-fill stages of growth when the high temperatures in June occurred. The highest temperature for the year was 106F, recorded for June 20, 21, and 22. Compounded by dry conditions at the time, these high temperatures caused considerable damage to the wheat crop. Low test weights and reduced yields were common even in irrigated wheat.

Dr. Dean Bark, state climatologist in the KSU office of Extension Computer Systems, calculated that 1988 precipitation amounts and distribution throughout the year matched up closest with those experienced in 1921. More recently, 1980 was the seventh best match and 1985 the fourteenth.

Table 1. Climatic data summary from the Northwest Research-Extension Center, September 1987 through December 1988.

Climatic	1987				1988													
feature	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Seas.[1]	Annual
Monthly Air Temperature, F																		
Average	61	50	40	30	20	29	38	46	61	71	76	75	64	50	40	33	66	50
70-year average	65	53	38	29	26	31	38	49	59	70	77	75	65	53	38	29	66	51
Maximum Air Temperatures, F																		
Actual	96	90	76	69	57	65	88	84	94	106	102	103	98	87	79	72	106	106
Monthly average	80	68	53	43	32	42	54	62	75	91	91	91	80	66	56	49	82	66
70-year monthly avg.	80	68	52	42	40	45	51	63	73	84	91	89	80	68	52	42	80	65
Minimum Air Temperatures, F																		
Actual	35	20	14	1	-19	-13	3	21	30	50	50	42	40	20	11	1	21	-19
Monthly average	46	32	26	16	8	15	22	31	47	60	60	60	48	34	24	17	51	36
70-year monthly avg.	50	37	24	16	13	18	24	36	46	56	62	60	50	37	24	16	52	38
Growing-Degree Units[2]																		
Monthly total	454	290	112	45	9	41	143	202	406	657	699	689	448	263	134	62	3102	3744
30-year average	471	303	101	43	32	55	107	225	383	580	735	686	471	303	101	43	3080	3721
Wind Velocity, mph																		
Monthly average	2.2	3.7	4.0	3.9	4.4	4.8	6.5	5.1	6.7	4.3	4.4	5.1	4.9	3.8	5.0	4.8	5.0	5.0
15-year average	4.6	4.1	4.0	4.1	4.3	4.7	4.6	6.0	5.2	5.0	4.5	4.4	4.6	4.1	4.0	4.1	4.9	4.7
Evaporation, inches																		
Monthly average	8.43	---	---	---	---	---	---	6.52	11.14	13.19	12.64	12.95	9.06	---	---	---	65.50	---
15-year average	9.34	---	---	---	---	---	---	7.49	9.32	12.05	13.49	11.63	9.34	---	---	---	63.33	---
Precipitation, inches																		
Monthly total	0.22	0.00	1.03	0.35	1.01	0.21	0.32	2.01	4.12	0.88	2.06	3.35	2.42	0.05	0.43	0.14	15.04	17.40
70-year average	1.46	1.07	0.62	0.44	0.35	0.52	1.13	1.80	2.94	3.12	2.95	2.22	1.46	1.07	0.62	0.44	14.49	18.62
Snowfall, inches																		
Monthly total	0.0	0.0	5.2	5.1	14.0	3.3	7.6	7.5	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.7	7.5	35.6
70-year average	0.0	0.5	3.4	4.7	3.7	4.8	7.3	2.9	0.2	0.0	0.0	0.0	0.0	0.5	3.4	4.7	3.1	27.6

1 Seasonal, April through September.

2 Computed according to NOAA method for corn.

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Table 2. Precipitation amounts recorded at the Northwest Research-Extension Center during 1988. Readings were taken at 8:00 a.m. and are applicable to the preceding 24-hour period.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	------	------	------	------	------	------	inches	------	------	------	------	------	------
1		T		T		0.20	T						
2		T		0.94	0.81	0.06							
3		0.17		T	1.25	0.27							
4		0.03				0.01		0.79		T	T		
5	T	T				0.05		0.26		T			
6	0.04	T					0.03			0.03			
7	0.09				T		0.22			0.02		T	
8			0.02				0.05	0.04				T	
9	T			0.06	T		T				0.04		
10		0.01									0.07		
11		T	T										
12			T				0.40		0.03			T	
13							0.16		0.17				
14						0.01			0.95				
15							0.17		0.72		T	0.02	
16			0.08				0.06				0.11	0.04	
17			0.16										
18	T		T	0.87	0.52			0.20		T			
19	0.63						0.60	1.89	0.41				
20	0.25	T			0.16	T		T				0.08	
21		T			0.37								
22				T	0.31								
23		T			0.12			T					
24				T	0.16		T	T					
25			T	0.03									
26			T	0.11		0.08	0.34	T			0.21		
27								0.17			T		
28									T				
29						0.12			T				
30						0.08	0.03		0.14				
31			0.06		0.82								
Total	1.01	0.21	0.32	2.01	4.52	0.88	2.06	3.35	2.42	0.05	0.43	0.14	17.40
Cumulative	1.01	1.22	1.54	3.55	8.07	8.95	11.01	14.36	16.78	16.83	17.26	17.40	17.40
70-year avg	0.35	0.52	1.13	1.80	2.94	3.12	2.95	2.22	1.46	1.07	0.62	0.44	18.62
Deviation	0.66	-0.31	-0.81	0.21	1.58	-2.24	-0.89	1.13	0.96	-1.02	-0.19	-0.30	-1.22
Cumul. dev.	0.66	0.35	-0.46	-0.25	1.33	-0.91	-1.80	-0.67	0.29	-0.73	-0.92	-1.22	-1.22

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Table 3. Weather facts not available from other tables, Northwest Research-Extension Center, 1988.

1. Number of days maximum air temperature equaled or exceeded 100F by month: 9 in June, 3 in July, and 2 in August.

2. Number of days minimum air temperature was 0F or lower by month: 11 in January and 5 in February.

3. Greatest temperature spread between maximum and minimum air temperature per 24-hour reporting period was 55F (March 28 and October 23).

4. Most rainfall received during a 24-hour reporting period ending at 8:00 a.m. was 1.89 inches on August 19.

5. Greatest amount of water evaporated from a free-water source during a 24-hour reporting period was 0.88 inch on July 5.

6. Length of freeze-free period (last 32F in the spring to the first in the fall) was 152 days (May 4 to October 2), whereas the longtime average is 160 days (May 2 to October 10).

Table 4. Long-time average degree days to selected base temperatures, Northwest Research-Extension Center.

Base temp.	Heating degree units[1]												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
65	1212	949	871	468	202	45	0	0	117	385	810	1091	6150
60	1057	809	716	326	109	15	0	0	52	251	660	936	4931
57	964	725	633	245	65	8	0	0	28	185	570	843	4266
55	902	669	574	197	43	0	0	0	18	149	510	781	3843
50	747	542	435	104	13	0	0	0	6	72	364	626	2909

Base temp.	Cooling degree units[2]												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
55	0	0	13	29	188	470	667	598	312	83	0	0	2360
57	0	0	0	17	149	413	605	536	262	58	0	0	2049
60	0	0	0	8	100	330	512	443	196	31	0	0	1620
65	0	0	0	0	37	210	361	293	111	10	0	0	1022
70	0	0	0	0	11	121	220	158	48	0	0	0	558

Source: NOAA, using data collected at the Northwest Research-Extension Center, 1951-80.

[1] Daily HDU = BaseT - [(MaxT + MinT)/2]

[2] Daily CDU = [(MaxT + MinT)/2] - BaseT

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Table 5. Probabilities that the monthly precipitation will be equal to or less than the indicated amount, Northwest Research-Extension Center.

Prob.	Monthly precipitation, inches											
Level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	0.00	0.00	0.05	0.23	0.89	0.59	0.70	0.26	0.05	0.05	0.01	0.02
0.10	0.01	0.01	0.14	0.35	1.17	0.89	0.99	0.42	0.11	0.11	0.04	0.05
0.20	0.06	0.05	0.30	0.57	1.59	1.40	1.44	0.71	0.28	0.23	0.11	0.11
0.30	0.11	0.10	0.47	0.77	1.95	1.87	1.85	0.99	0.48	0.37	0.19	0.16
0.40	0.17	0.16	0.65	0.97	2.30	2.36	2.26	1.28	0.72	0.52	0.28	0.22
0.50	0.24	0.24	0.85	1.20	2.66	2.90	2.69	1.61	1.02	0.70	0.39	0.29
0.60	0.33	0.35	1.09	1.46	3.07	3.51	3.17	2.00	1.40	0.92	0.51	0.38
0.70	0.44	0.49	1.38	1.77	3.54	4.25	3.75	2.47	1.89	1.21	0.68	0.48
0.80	0.61	0.69	1.79	2.20	4.15	5.23	4.51	3.10	2.61	1.61	0.92	0.62
0.90	0.89	1.06	2.47	2.88	5.10	6.83	5.72	4.15	3.86	2.29	1.31	0.85
0.95	1.17	1.43	3.14	3.54	5.99	8.36	6.86	5.16	5.13	2.97	1.71	1.08

Table 6. Probabilities of freeze dates and freeze-free periods at the Northwest Research-Extension Center.

Temp., °F	Probabilities of: a later spring freeze date (month/day) than indicated								
	.90	.80	.70	.60	.50	.40	.30	.20	.10
36	4/30	5/05	5/08	5/11	5/14	5/17	5/20	5/23	5/28
32	4/21	4/25	4/28	5/01	5/03	5/06	5/08	5/11	5/15
28	4/08	4/13	4/17	4/20	4/23	4/26	4/29	5/03	5/08
24	3/30	4/03	4/06	4/09	4/11	4/13	4/16	4/19	4/23
20	3/20	3/25	3/29	4/01	4/04	4/07	4/10	4/13	4/18
16	3/12	3/17	3/21	3/24	3/27	3/30	4/02	4/05	4/10
	an earlier fall freeze date (month/day) than indicated								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	9/12	9/17	9/21	9/24	9/27	9/30	10/03	10/07	10/12
32	9/19	9/25	9/29	10/02	10/06	10/09	10/12	10/17	10/22
28	10/06	10/11	10/14	10/17	10/20	10/22	10/25	10/29	11/02
24	10/13	10/18	10/21	10/24	10/27	10/30	11/02	11/05	11/10
20	10/21	10/26	10/30	11/02	11/05	11/08	11/12	11/16	11/21
16	10/31	11/04	11/08	11/10	11/13	11/15	11/18	11/21	11/26
	a longer freeze-free period (days) than indicated								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	158	150	145	140	135	131	126	120	112
32	176	169	163	159	155	151	146	141	133
28	199	192	187	183	179	175	171	166	159
24	216	210	205	202	198	195	191	187	181
20	239	230	225	220	215	210	205	199	191
16	252	244	239	234	230	226	221	216	209

Source: NOAA, based on data collected at the NWREC, 1951-80.

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Crop Performance Tests

J. R. Lawless

Crop performance tests include both public and private varieties or hybrids. Private entries in performance tests are solicited from commercial companies and are tested on a fee basis. Performance tests conducted annually at Colby include wheat, soybeans, grain sorghum, sunflowers, and corn. Performance test results, published annually, include data from tests throughout the state and are designed to provide growers with unbiased information to help them choose hybrids or varieties sold in Kansas. Copies of the following 1988 performance test reports are available in county extension offices:

1988 Performance Tests with Winter Wheat Varieties, KAES Report of Progress 551

1988 Kansas Corn Performance Tests, KAES Report of Progress 560

1988 Kansas Sorghum Performance Tests, Grain and Forage, KAES Report of Progress 562

1988 Kansas Sunflower Performance Tests, KAES Report of Progress 563

1988 Kansas Soybean Performance Tests, KAES Report of Progress 564

1988 Kansas Variety Tests--Spring Oats, Spring and Winter Barley, Spring Wheat, KAES Report of Progress 565

1988 Kansas Alfalfa Performance Tests, KAES Report of Progress 566

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Crop Variety Tests

J. R. Lawless

Several tests are conducted annually to provide varietal information on crops not included in official Kansas State University performance tests. Varietal tests may include both private and public entries. Private entries are included with the permission of the parent company but with no charge. The individual tests are conducted utilizing acceptable statistical methods described on page 1. Varietal tests conducted during 1988 included spring oats, winter and spring barley, spring wheat, and winter rape.

Northwest Research-Extension Center, Kansas State University

Winter Barley Variety Test, after Fallow

J. R. Lawless

Data from tests since 1985 are summarized in Table 1. Differential winter damage occurred in 1986 and 1988. No damage occurred in 1985 or 1987. Hail in 1986 caused severe stem and head damage and reduced yields that year. Insufficient soil surface moisture at planting time in the fall of 1987 resulted in poor stands and reduced yields in 1988.

None of the varieties tested have been outstanding in all characteristics, and no available variety is hardy enough to produce consistently in northwestern Kansas. Kanby performed well in both 1987 and 1988, but yielded less than all varieties in 1985 and 1986. Dundy, one of the hardiest varieties presently available, performed well during the 4-year summary period but lodged more severely than other varieties. Hitchcock, also a relatively hardy variety, performed well during the period and exhibited excellent standability. Post, less hardy than other varieties tested, has exhibited outstanding yield potential in the absence of severe winter damage. Schuyler yielded well during the period but tested low in bushel weight every year.

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Table 1. Agronomic data from tests on winter barley varieties grown after fallow, Northwest Research-Extension Center, 1985-1988[1].

Variety	Grain yield		Test wt.		Spring stand		Plant height		Maturity[3]		Lodging	
	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[4]
	bu./acre		lbs./bu.		---%---		inches		days		---%---	
Dundy	53	57	49.1	46.7	85	96	25	25	140	133	0	41
Hitchcock	52	56	48.2	47.7	84	95	28	29	144	137	0	2
Kanby	57	50	49.7	47.9	88	96	31	30	138	132	0	29
Post	54	57	49.5	46.6	60	87	28	29	142	134	0	1
Schuyler	50	57	42.4	44.3	84	92	26	28	150	141	0	3
Test Avg.	53	55	47.8	46.6	80	93	28	28	143	135	0	15
LSD.05	6	--	1.2	----	9.0	--	1.2	--	1.2	---	-	--

[1] 1988 test site was fertilized with 40 pounds N per acre preplant and planted on September 24, 1987, at a seeding rate of 45 pounds per acre. Plots were harvested on June 24, 1988.

[2] Four-year average, 1985, 1986, 1987, and 1988.

[3] Days from January 1 to heading.

[4] Three-year average, 1985, 1986, and 1987. Lodging notes not obtained in 1986 because of severe hail damage.

Tending wheat plots in a seed quality study, KSU Northwest Research-Extension Center, 1988.

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Winter Barley Variety Test, under Irrigation

J. R. Lawless

Data for the 1985 through 1988 period are summarized in Table 1. Dundy had best yield averages but lodged severely. Hitchcock yielded slightly less but exhibited much less lodging. Post, a less hardy variety, also yielded well in the absence of severe winter damage. Schuyler had the poorest test weight and yield averages.

Table 1. Agronomic data from tests on winter barley varieties grown under irrigation, Northwest Research-Extension Center, 1985-1988[1].

	Grain yield		Test wt.		Spring stand		Plant height		Maturity[3]		Lodging	
Variety	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]	1988	Avg.[2]
	bu./acre		lbs./bu.		---%---		inches		days		---%---	
Dundy	116	90	43.7	43.6	100	100	30	32	136	131	0	63
Hitchcock	97	82	46.5	46.1	100	100	35	36	138	134	0	16
Kanby	107	81	48.0	45.8	100	100	36	37	134	129	0	62
Post	105	86	48.5	46.6	95	98	34	36	137	131	0	40
Schuyler	84	74	43.3	43.2	78	94	33	33	148	138	0	35
Test Avg.	102	83	46.0	45.1	95	98	34	35	139	133	0	43
LSD.05	6.0	--	1.1	----	6.0	--	1.1	--	0.3	---	-	--

[1] 1988 test site was planted on September 17, 1987 in a sprinkler-irrigated area previously fertilized with 117 pounds N per acre. Prior to planting, irrigation water was applied to wet the soil 3 to 4 feet deep. Four 1.25-inch irrigations were applied during the spring months. Plots were harvested on June 24, 1988.

[2] Four-year average, 1985, 1986, 1987, and 1988.

[3] Days from January 1 to heading.

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Spring Barley, Oats, and Wheat Variety Tests, after Fallow

J. R. Lawless

Data obtained in 1986, 1987, and 1988 are given in Table 1. Hail in May 1986, just prior to the heading stage, caused severe crop damage. High temperatures prior to maturity in 1988 resulted in reduced yields, test weights, and grain quality.

Average spring oat yields exceeded those of barley and wheat every year. Spring wheat yielded less than barley each year. Ogle oats had the best 1988 and 3-year yield averages. Otis and Steptoe spring barley had similar 3-year average yields, but Otis was best in 1988. Oslo had the highest spring wheat yields in 1988 but averaged less than Guard during the 3-year period.

Lodging and test weight characteristics also should be considered when choosing spring small grain varieties. Otis exceeded other barley varieties in test weights, but all varieties had low averages. Starter, Bates, and Don had the highest average test weights for oats. Guard had the best test weight average among spring wheats. Ogle and Larry oats and NAPB Lud barley had the lowest lodging averages for spring oats and barley, respectively. No lodging occurred in spring wheat varieties.

9-17

Table 1. Agronomic data from tests on spring barley, oats, and wheat varieties grown after fallow, Northwest Research-Extension Center, 1986-1988[1].

Crop and variety	Grain yield 1988	Grain yield avg.[2]	Grain yield 1988	Grain yield avg.[2]	Height 1988	Height avg.[2,3]	Test weight 1988	Test weight avg.[2,4]	Lodging 1988	Lodging avg.[2,5]	Heading date 1988	Heading date avg.[2,5]
	lbs./acre		bu./acre		inches		lbs./bu.		-----%------		mo. day	
Spring barley												
Bowers	2039	1574	42	33	32	29	34.7	38.8	53	71	6-2	6-2
NAPB Lud	1518	1941	32	40	24	26	32.4	39.9	8	13	6-5	6-5
Otis	2809	2042	59	43	25	24	43.2	42.5	11	55	5-30	5-30
Steptoe	2049	2020	43	42	30	27	33.8	37.9	0	37	5-31	6-1
Average	2104	1894	44	39	28	27	36.0	39.8	18	44	6-2	6-2
LSD (.05)	107	----	2.2	--	1.0	--	1.3	----	5.1	--	0.7	----
Spring oats												
Bates	2297	2431	72	76	30	33	32.6	34.5	0	22	5-28	5-29
Don	2292	2380	72	74	29	30	31.9	34.2	0	17	5-30	5-30
Larry	2104	2479	66	77	30	31	28.8	32.3	0	11	5-31	5-31
Ogle	2348	2664	73	83	32	33	28.8	31.1	0	9	5-31	6-1
Starter	2247	2317	70	72	32	33	34.2	34.9	0	18	5-29	5-29
Average	2258	2454	71	77	30	32	31.3	33.4	0	15	5-30	5-30
LSD (.05)	126	----	3.9	--	0.9	--	0.7	----	-	--	0.2	----
Spring wheat												
Guard	1459	1287	25	21	28	28	51.8	53.0	0	0	6-1	6-2
NAPB Oslo	1741	1162	29	19	28	26	53.6	50.9	0	0	5-29	5-31
Larned (winter wheat)	659	843	10	14	29	32	47.7	50.4	0	0	6-8	----
Average	1286	1097	21	18	28	29	51.0	51.4	0	0	6-2	----
LSD (.05)	120	----	2.0	--	0.8	--	0.6	----	-	-	0.4	----

[1] The 1988 test was planted on February 26 at a seeding rate of 75 lbs./acre for barley, 64 lbs./acre for oats, and 100 lbs./acre for wheat. Fertilizer rate was 40 lbs. N/acre.
[2] 1986, 1987, and 1988.
[3] No height notes obtained on spring barley in 1987 because of severe lodging.
[4] Test weight for wheat not obtained in 1986.
[5] No lodging or heading date obtained in 1986 because of severe hail damage just prior to time of heading.

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Winter Rape Variety Test, after Fallow

J. R. Lawless

Introduction

A winter rape variety test was grown in 1988. Previous investigations of both winter and spring rape were conducted for several years at Colby but were suspended in 1987. The 1988 variety test was included as part of the National Winter Rapeseed Variety Trials and was coordinated by Dr. D. L. Auld and Karen A. Mahler, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, Idaho.

Procedures

The site was a Keith silt loam that had been fallowed one season following irrigated sunflowers. The plots were seeded at a rate of 7 lbs. per acre on September 1, 1987. Dry soil conditions at planting resulted in slow emergence and less than desired fall stands. No winter damage was observed. Plants were cut on June 24, 1988 and allowed to air dry prior to threshing. Grain samples were submitted to the University of Idaho for oil analysis.

Results and Discussion

Data obtained are summarized in Table 1. Significant differences were obtained for all characteristics measured. Stand deficiencies may have affected variety performance. Yields of all varieties except Cascade were similar and not significantly different. Cascade yielded significantly less grain than several varieties included. Significant differences were obtained for oil percent. Additional data are needed prior to making conclusions concerning varietal selection.

9-19

Table 1. Agronomic data from tests on winter rape grown after fallow, Northwest Research-Extension Center, 1988.

Variety	Stand[1]	Bloom date	Plant height	Grain yield	Oil
	%	May	inches	lbs/A	%
Bienvenu	91	4	35	1302	40.0
Bridger	80	2	36	1224	40.0
Cascade	81	2	37	1045	38.5
Ceres	61	7	44	1322	----
Darmor	61	9	41	1320	----
Dwarf Essex	94	8	46	1328	40.1
Glacier	94	5	42	1382	39.1
Jet Neuf	80	5	37	1216	37.7
Jupiter	85	4	44	1342	----
Santana	84	5	43	1241	----
Average	81	5	41	1272	39.2
LSD (.05)	18	1	3	235	0.8

[1]Stand deficiencies resulted from dry soil conditions at planting and poor emergence. No winter damage observed.

Seeding industrial rapeseed plots,
KSU Northwest Research-Extension Center, 1988.

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Northwest Research-Extension Center, Kansas State University

Seed Quality of Winter Wheat as Related to Crop Management Practices, 1988

J. R. Lawless

Summary

Effects of seeding rate and fungicide application were compared for six winter wheat varieties grown with uniform high fertility, irrigation, and Cerone applications. Fungicide application significantly increased both yield and seed size. Tilt was more effective than either Bayleton or mancozeb fungicides. Significant seeding rate differences were obtained but were probably influenced by less than normal germination and emergence with each of the rates. Several significant variety x fungicide, variety x seeding rate, and fungicide x seeding rate interactions were obtained, indicating a need for considerations of specific variety-seeding rate-fungicide application.

Introduction

Preliminary data from 1985 and 1986 studies evaluating the effects of several intensive management practices on seed quality and yield characteristics of Larned and TAM 105 wheats revealed several varietal-treatment interactions in regard to both seed quality and yield characteristics.

Seed quality and yield characteristics were enhanced by fungicide application to five wheat varieties in 1987, but no significant varietal-fungicide interactions were detected. Seeding rate effects were highly variety-dependent.

The 1988 study was again directed toward determination of effects of variations in seeding rate and foliar disease control on seed quality and other characteristics of winter wheat grown under conditions of intensified management, including supplemental irrigation, high soil fertility, and uniform Cerone applications.

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Procedures

A split-split plot design with four replications was utilized for the test. Fungicide treatment was the main variable. Variety and seeding rate were included as first and second splits, respectively. A level-border irrigated site on the Northwest Resarch-Extension Center was used for the test. A 6-inch water application was made to the area prior to planting to wet the soil profile to near capacity throughout the root zone. Fall preplant fertilizer applications included 40 pounds P_2O_5 and 110 pounds N per acre.

Certified or above classification seed of each of the varieties included in the test was obtained from T. L. Walter, Agronomy Department, KSU. Thousand kernel weights (TKW) were determined for each of the varieties, and seed was packaged accordingly for individual plots at the proposed planting rates of 650,000, 1,300,000, and 1,950,000 seeds per acre. TKW values for each of the varieties were as follows: Newton--29 grams: Hawk--42 grams; TAM 107--35 grams; Vona--31 grams; Brule--35 grams; and Norkan--34 grams. The test was planted on September 18, 1987 with a three-point, four-row, hoe-type nursery planter equipped with a spinner-type seed distributor. Germination and emergence were slow because of dry soil conditions at planting. Initial stands were less than desired, particularly at the lowest seeding rate. Planted plots were 5 feet wide and 16 feet long. Plot lengths were trimmed to 10 feet in the spring of 1988 to provide adequate alley width to accommodate tractor travel during foliar treatment applications. Foliar application of an additional 50 pounds N per acre was made on March 1, 1988. A blanket application of Cerone (.5 pt./acre) was made on May 9, 1988.

Tilt fungicide was applied on May 9, 1988 at approximate growth stage 7 to 8 (Feekes' scale). Bayleton and mancozeb fungicide treatments were applied on May 16, 1988 when growth stages (Feekes' scale) ranged from 9 for the latest variety (Brule) to 10 for the earliest variety (TAM 107). Each of the fungicides was applied in solution with water at a 20-gallon-per-acre rate and was applied with a field sprayer equipped with a PTO-driven pump and a 12-foot, side-mounted boom extended across the full length of the plots from the trimmed alleyways. Boom height was adjusted to approximately 20 inches above the growing wheat. Fungicides were applied at the following rates: Bayleton--4 oz. material/acre; Tilt--4 oz. solution/acre; and mancozeb--2 lbs material/acre.

The test was irrigated on May 11, 1988 with approximately 6 acre-inches of water per acre. Harvest was hastened by extremely hot, dry conditions in late June and was completed on July 3, 1988.

Data were obtained during the season on the following plant and seed characteristics: heading date, height, yield, bushel weight, TKW, protein percent, and seed size distribution. Seed size distribution was determined by sieving a weighed quantity of seed through 6/64 and 5/64 x 3/4 inch slotted sieves and determining the percent seed that (1) stayed on top of the 6/64 sieve, (2) passed through the 6/64 sieve but stayed on top of 5/64 sieve, or (3) passed through both sieves. Analysis of protein percent was obtained from samples submitted to Dr. D. L. Wetzel, Grain Science and Industry, KSU, for infrared protein screening.

Results and Discussion

Disease Information

Varietal information on the relative susceptibility or resistance to several foliar diseases is included in Table 1. Effectiveness ratings of disease protection proffered by the fungicides are given in Table 2. Leaf rust ratings obtained in 1988 are summarized in Table 3. These ratings were supplied by Dr. W. G. Willis, Plant Pathology Dept., KSU, from readings made on individual plots on June 15, 1988, approximately 1 month after fungicide application. Leaf rust was severe during the 1988 season, as indicated by the high average ratings for all plots, regardless of treatment. Very little protection from the fungicides was indicated at the time of rating, as shown by similar ratings from fungicide-treated and untreated plots.

Table 1. Wheat variety disease ratings[1].

	Foliar disease				
Variety	Leaf rust	Stem rust	Speckled leaf blotch	Tan spot	Powdery mildew
			Rating[2]		
Newton	S	I	S	S	I
Hawk	MS	MR	S	S	I
TAM 107	S	I	MS	MS	R
Vona	S	MS	MS	S	I
Brule	I	MR	MS	S	MS
Norkan	MS	R	--	S	I

[1]Data taken from "Wheat Variety Disease and Insect Ratings - 1988," William G. Willis, Extension Plant Pathologist, Ag Facts, KSU Cooperative Extension Service, AF-110 revised, Aug. 1988.
[2]Rating codes: R = resistant; MR = moderately resistant; I = intermediate; MS = moderately susceptible; S = susceptible.

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Table 2. Foliar fungicides for wheat[1].

Fungicide	Trade name	Effectiveness Ratings[1,2] Leaf blotch	Rusts	Powdery mildew	Tan spot
Mancozeb	Dithane M-45 Manzate 200	G	G	P	F
Triadimefon	Bayleton	F	VG[3]	E	P
Propiconazole	Tilt	G	VG	E	G

[1]Information from Wheat Leaf Disease Fungicides, William G. Willis, Extension Plant Pathologist, Ag Facts, KSU Cooperative Extension Service. AF 167, February 1988.
[2]Effectiveness ratings: E = Excellent; VG = Very Good; G = Good; F = Fair; P = Poor.
[3]Bayleton rust control VG only at high rates.

Table 3. Leaf rust disease ratings, Northwest Research-Extension Center, 1988.

Variety	Fungicide: Bayleton	Tilt	Mancozeb	None
	Ratings[1]			
Newton	4.00	4.75	4.50	4.00
Hawk	4.75	4.75	4.25	4.75
TAM 107	5.00	4.75	4.50	4.75
Vona	4.50	4.50	4.50	4.50
Brule	4.00	4.00	4.00	4.00
Norkan	4.00	4.00	4.00	4.00

[1]Rated: 1 = little or no leaf rust to 5 = severe rust. Ratings given are average of 4 replications.

Fungicide Effects

Summary data for fungicide effects are included in Table 4. Significant differences were obtained for yield, TKW, and seed size distribution. Tilt fungicide produced the greatest improvement in yield, TKW, and percent large seed. The application of Tilt resulted in decreased percentages of seed in both the medium and small classes. Mancozeb and Bayleton reduced the percent small seeds but had little effect on the percentage of medium seed. The excellent response to Tilt appears contrary to leaf rust ratings obtained (Table 3), which indicated little

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difference in fungicide effectiveness. Possibly greater differences might have been detected, if earlier ratings had been made. Protection against leaf diseases other than rust also might have been involved in the positive reaction obtained for fungicide treatment. These results indicate excellent potential for utilizing fungicides to improve wheat seed quality and yield characteristics.

Table 4. Data summary for fungicide effects 1988 wheat seed quality study, KSU Northwest Research-Extension Center, 1988.

Fungicide	Heading date,	Height,	Yield,	Test weight,	TKW	Protein,	Seed size distribution >6/64	5/64-6/64	<5/64
	May	inches	bu/ac	lb/bu	grams	-----------	--------%--------	-----------	
Tilt	19.9	34.3	64.3	53.8	21.5	13.0	21.3	56.2	22.5
Bayleton	20.0	34.2	58.6	52.4	20.2	12.8	13.1	60.7	26.2
Mancozeb	19.8	32.7	56.6	53.8	20.2	12.9	14.3	61.5	24.2
none	19.1	33.3	53.1	52.5	19.1	12.7	10.4	61.0	28.6
LSD (0.05)	NS	NS	10.3	NS	1.0	NS	3.3	3.0	2.6

Varietal Effects

Varieties included in the 1988 study were selected to ascertain the potential effects of fungicide application and seeding rate variables on different genetic stocks. Varieties included were those most widely grown in the area in recent years and represent a diversity of in plant characteristics and genetic background. Those differences are emphasized in the varietal data summary (Table 5), because significant differences are indicated for all characteristics measured. Varietal differences will be discussed only as they relate to fungicide x variety and/or variety x seeding rate interactions.

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Table 5. Data summary for varietal effects 1988 wheat seed quality study, KSU Northwest Research-Extension Center, 1988.

Variety	Heading date,	Height,	Yield,	Test weight,	TKW	Protein,	Seed size distribution >6/64	5/64-6/64	<5/64
	May	inches	bu/ac	lb/bu	grams	----------%----------			
Newton	18.9	34.3	60.2	53.8	19.2	12.8	12.2	61.2	26.6
Hawk	20.4	33.6	50.6	50.9	19.9	13.3	14.7	63.9	21.4
TAM 107	16.9	32.2	70.5	55.4	25.2	12.5	22.7	63.9	13.5
Vona	20.3	32.6	52.9	51.6	17.2	12.7	2.8	56.9	40.3
Brule	22.9	36.5	57.0	51.3	18.1	12.3	7.4	58.9	33.6
Norkan	19.1	32.4	57.7	55.6	21.8	13.5	28.8	54.2	17.0
LSD (.05)	0.6	0.8	3.6	1.0	0.8	0.3	3.2	2.9	3.0

Fungicide X Varietal Effects

Summary data are presented in Table 6.

Although only nonsignificant varietal x fungicide yield differences were indicated by the analysis, certain trends were observed. TAM 107 and Vona appeared to respond most to Tilt application. Newton appeared equally responsive to Tilt, Bayleton, and mancozeb. Hawk and Norkan were least responsive to Bayleton; and Hawk and Brule were least responsive to mancozeb.

The effectiveness of the fungicides in increasing the percent seed greater than 6/64 varied considerably among varieties. Response for each of the varieties was best with Tilt. TAM 107 exhibited the greatest seed size increase in response to each of the fungicides. Responses for Vona and Brule were minor, regardless of kind of fungicide. Newton and Norkan exhibited less response to Bayleton than to mancozeb, but Hawk's reaction to those fungicides was the opposite.

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Table 6. Data summary for fungicide x varietal effects in a wheat seed quality study, KSU Northwest Research-Extenion Center, 1988.

Fungicide	Variety	Heading date,	Height,	Yield,	Test weight,	TKW	Protein,	Seed size distribution >6/64	5/64-6/64	<5/64
		May	inches	bu/ac	lb/bu	grams	----------%----------			
Tilt	Newton	19.1	35.3	63.6	54.2	19.6	13.1	15.1	59.7	25.2
Tilt	Hawk	20.6	34.7	56.7	52.0	21.7	13.6	23.6	59.0	17.4
Tilt	TAM 107	17.0	32.3	80.8	56.3	27.6	12.4	39.1	50.1	10.8
Tilt	Vona	20.3	33.1	60.8	52.6	18.3	12.9	4.6	60.7	34.7
Tilt	Brule	23.1	37.4	62.1	51.7	19.2	12.2	9.5	59.3	31.2
Tilt	Norkan	19.3	32.8	61.5	55.8	22.7	14.0	35.8	48.4	15.9
Bayleton	Newton	19.1	35.3	62.7	53.1	19.2	12.8	11.2	62.0	26.8
Bayleton	Hawk	20.9	34.2	50.4	50.1	19.8	13.4	14.3	63.7	22.0
Bayleton	TAM 107	17.0	32.7	69.8	54.7	25.2	12.5	19.3	67.1	13.7
Bayleton	Vona	20.4	33.2	52.5	51.3	17.5	12.6	2.2	57.8	40.0
Bayleton	Brule	23.0	37.1	59.0	50.5	18.1	12.0	6.8	57.3	35.9
Bayleton	Norkan	19.7	32.6	57.3	54.4	21.2	13.6	24.7	56.3	19.0
mancozeb	Newton	19.1	32.8	60.0	54.7	19.5	12.7	14.1	62.4	23.5
mancozeb	Hawk	20.4	32.0	48.4	51.1	19.2	13.5	11.1	67.2	21.7
mancozeb	TAM 107	16.8	31.7	67.9	55.9	24.5	12.5	19.9	65.9	14.2
mancozeb	Vona	20.4	32.3	51.6	52.0	17.4	12.7	2.4	57.7	39.9
mancozeb	Brule	23.4	35.4	53.5	51.9	17.9	12.6	7.1	61.1	31.8
mancozeb	Norkan	18.8	31.8	58.1	57.0	22.4	13.5	31.2	54.4	14.3
none	Newton	18.1	33.8	54.7	53.1	18.3	12.6	8.6	60.6	30.8
none	Hawk	19.7	33.4	46.9	50.6	18.9	12.8	9.8	65.8	24.4
none	TAM 107	16.7	32.0	63.5	54.9	23.6	12.6	12.3	72.4	15.2
none	Vona	19.8	31.8	46.6	50.3	15.5	12.8	1.8	51.7	46.5
none	Brule	21.9	36.1	53.3	51.0	17.4	12.3	6.3	58.1	35.6
none	Norkan	18.8	32.6	53.9	55.4	21.0	13.1	23.7	57.5	18.8
LSD (.05)		NS	NS	NS	NS	NS	NS	6.3	5.7	NS

The data also indicated significant varietal x fungicide effects on seed falling in the 5/64 to 6/64 classification. These effects were quite varied and were definitely related to changes in the amount of seed falling in the large seed size fraction (> 6/64). Varieties with the greatest fungicide response in terms of percent increase in seed greater than 6/64 had an accompanying decrease in seed 5/64 to 6/64, whereas less responsive varieties exhibited little change in that seed portion. One exception was Vona, which exhibited the least increase in large seed but a substantial increase in seed 5/64 to 6/64 in size and an accompanying decrease in percent seed less than 5/64 in size.

The fungicide x variety interaction effect on total seed greater than 5/64 in size may also be of interest, since separation using that criterion may be necessary in some years or when processing certain varieties. The individual fungicidal effects are less pronounced and somewhat different relative to individual varieties than when considering the effect on seed greater than 6/64. Tilt

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generally had the greatest overall effect but did not produce the greatest increase for all varieties. Both Newton and Norkan responded equally well or better to mancozeb. Vona, the variety with the least response in percent large seed (> 6/64) regardless of fungicide, exhibited the greatest response to each of the fungicides when 5/64 was used as the minimum. Conversely, TAM 107 exhibited the largest increase in percent seed larger than 6/64 but was less responsive than most other varieties in terms of seed larger than 5/64.

In general, regardless of variety or size separation indicator used, Tilt appeared to have equal or greater potential than either Bayleton or mancozeb for increasing seed size.

Seeding Rate Effects

Seeding rate effects are summarized in Table 7. Significant differences were obtained for all characteristics measured, except height. Increasing the seeding rate resulted in earlier heading and increased yields, test weights, TKWs, and percent large seed. Protein percent and percent small seed decreased with increased seeding rates. The high seeding rate generally produced the best seed quality characteristics. Protein percent was an exception. Effects produced by increasing the seeding rate from 650,000 to 1,300,000 seeds/acre were considerably greater than those of changing from 1,300,000 to 1,950,000 seeds/acre. The predictive value of the 1988 data, however, may be questionable. Dry topsoil conditions at planting time in 1987 resulted in reduced germination and emergence of wheat from all seeding rates and especially from the low seed rate. Results were undoubtedly influenced by those conditions.

Table 7. Data summary for seeding rate effects in a wheat quality study, KSU Northwest Research-Extension Center, 1988.

Seeding rate	Heading date,	Height,	Yield,	Test weight,	TKW	Protein,	Seed size distribution >6/64	5/64-6/64	<5/64
1,000/ac.	May	inches	bu/ac	lb/bu	grams	-----------	-----%-----	-----------	
650	20.5	33.5	53.1	52.1	19.6	13.1	12.0	59.0	29.0
1,300	19.6	33.7	60.0	53.4	20.4	12.8	15.1	60.4	24.5
1,950	19.0	33.6	61.4	53.8	20.7	12.7	17.2	60.2	22.6
LSD (.05)	0.2	NS	1.1	0.4	0.3	0.1	0.7	1.0	1.1

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Fungicide X Seeding Rate Effects

Data are summarized in Table 8. A significant fungicide x seeding rate interaction was obtained for percent seed greater than 6/64 in size. Seeding rate increases had less effect on percent large seed with no fungicide application than when fungicide was applied. Tilt fungicide had a greater effect on seed size than did Bayleton or mancozeb, but response to seeding rate changes within the Tilt plots was similar to the change observed with Bayleton and mancozeb. Tilt-treated plots averaged approximately 100% more large seed (seed > 6/64 in size) than untreated plots at each of the seeding rates, whereas both Bayleton and mancozeb treatments produced approximately 25% more large seed than no fungicide.

Yields from untreated plots increased approximately the same amount as those from fungicide-treated plots when the seeding rate was increased from 650,000 to 1,300,000 seeds/acre. The planting rate increase from 1,300,000 to 1,950,000 seeds/acre did not increase yields of untreated plots but increased all fungicide-treated plots by 1 to 2 bushel per acre. However, this difference was statistically nonsignificant.

Table 8. Data summary for fungicide x seeding rate effects in a wheat seed quality study, Northwest Research-Extension Center, 1988.

Fungicide	Seeding rate	Heading date,	Height,	Yield,	Test weight,	TKW	Protein,	Seed size distribution >6/64	5/64-6/64	<5/64
	(1,000)	May	inches	bu/ac	lb/bu	grams	%	%	%	%
Tilt	650	20.8	34.2	60.0	53.0	21.0	13.2	18.3	56.2	25.5
Tilt	1,300	19.7	34.3	65.6	53.8	21.7	13.1	21.5	56.2	22.4
Tilt	1,950	19.2	34.3	67.2	54.5	21.8	12.8	24.1	56.2	19.7
Bayleton	650	20.7	33.9	53.5	51.4	19.6	13.0	10.5	60.4	29.1
Bayleton	1,300	20.0	34.4	60.6	52.7	20.2	12.8	13.6	60.9	25.5
Bayleton	1,950	19.3	34.2	61.7	52.9	20.6	12.7	15.2	60.7	24.1
mancozeb	650	20.7	32.7	50.8	52.5	19.5	13.1	10.8	60.2	28.9
mancozeb	1,300	19.7	32.7	58.2	54.2	20.2	12.9	14.2	62.6	23.2
mancozeb	1,950	19.2	32.6	60.8	54.6	20.9	12.8	17.9	61.6	20.5
none	650	19.9	33.2	48.1	51.6	18.4	12.9	8.4	59.0	32.6
none	1,300	19.1	33.4	55.5	52.8	19.5	12.7	11.2	61.9	26.9
none	1,950	18.4	33.2	55.7	53.2	19.5	12.6	11.6	62.2	26.2
LSD (.05)		NS	NS	NS	NS	NS	NS	1.5	NS	NS

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Variety X Seeding Rate Effect

Variety x seeding rate summary data are presented in Table 9. Several significant interactions were obtained. Characteristics significantly affected included yield, protein percent, percent seed > 6/64, and percent seed 5/64 to 6/64.

All varieties produced significantly better yields when planted at 1,300,000 seeds/acre than at 650,000. Most varieties produced slightly better yield at 1,950,000 than at 1,300,000 seeds/acre, but only Norkan produced a significantly better yield with the last seeding rate increase. Vona had the greatest yield range between high and low seeding rates (13.9 bu./A) and Newton the least (5.2 bu./A).

Protein was generally reduced with each seeding rate increase. The reduction for Hawk and Norkan appeared slightly greater than for other varieties.

Average percent seed > 6/64 in size was increased with increased seeding rate within each of the varieties. TAM 107 exhibited the greatest response to seeding rate increases (10.8%). Vona and Brule responded only slightly (less than 2%). Varieties reacted differently in respect to the effect of seeding rate on percent seed 5/64 to 6/64 in size. Newton, Hawk, and Brule had more seed in the 5/64 to 6/64 classification when planted at 1,300,000 seeds/acre than at 650,000, but did not respond additionally when the seeding rate was increased to 1,950,000 seeds/acre. Each seeding rate increase for Vona resulted in a substantial increase of seed in the 5/64 to 6/64 category. Both TAM 107 and Norkan were inversely affected by seeding rate increases. For both varieties, the greatest percent seed 5/64 to 6/64 in size was produced at the low seeding rate, and each produced less seed of that size with each seeding rate increase.

As indicated earlier in this report, the overall effect of seeding rate changes in 1988 was undoubtedly influenced by the difficulty in obtaining good stands in the fall of 1987, especially with low seeding rates. Varietal differences in ability to germinate and emerge from the planting depths necessitated by dry soil conditions may have additionally complicated the interaction effects obtained.

Table 9. Data summary for variety x seeding rate effects in a wheat seed quality study, KSU Northwest Research-Extension Center, 1988.

Variety	Seeding rate	Heading date,	Height,	Yield,	Test weight,	TKW	Protein,	Seed size distribution >6/64	5/64-6/64	<5/64
	(1,000)	May	inches	bu/ac	lb/bu	grams	-----------	%	---------	
Newton	650	19.6	34.1	57.0	52.5	18.5	13.0	9.7	60.1	30.2
Newton	1,300	18.7	34.4	61.5	54.4	19.4	12.8	12.8	61.7	25.5
Newton	1,950	18.3	34.4	62.2	54.4	19.6	12.7	14.2	61.7	24.1
Hawk	650	21.4	33.8	45.5	50.1	18.7	13.7	11.1	61.6	27.3
Hawk	1,300	20.0	33.8	53.0	51.4	20.3	13.2	15.2	65.2	19.6
Hawk	1,950	19.8	33.1	53.3	51.4	20.8	13.0	17.8	64.9	17.2
TAM 107	650	17.8	32.1	65.8	54.6	24.7	12.6	17.2	66.9	16.0
TAM 107	1,300	16.8	32.3	72.4	55.6	25.4	12.5	22.8	64.8	12.4
TAM 107	1,950	16.1	32.2	73.4	56.1	25.6	12.5	28.0	60.0	12.0
Vona	650	21.3	32.4	44.4	50.4	16.8	12.9	2.4	53.0	44.6
Vona	1,300	20.3	32.7	56.0	51.8	17.2	12.7	2.8	57.1	40.2
Vona	1,950	19.2	32.8	58.3	52.4	17.5	12.6	3.1	60.8	36.1
Brule	650	23.5	36.6	52.9	50.7	17.6	12.4	6.4	57.1	36.5
Brule	1,300	22.8	36.4	58.4	51.2	18.4	12.3	7.6	59.8	32.6
Brule	1.950	22.3	36.6	59.6	52.1	18.4	12.2	8.3	59.9	31.8
Norkan	650	19.7	32.1	53.2	54.5	21.5	13.8	25.3	55.0	19.7
Norkan	1,300	19.3	32.6	58.6	56.0	21.7	13.6	29.5	53.8	16.7
Norkan	1,950	18.5	32.6	61.3	56.4	22.3	13.3	31.7	53.7	14.6
LSD (.05)		NS	NS	2.6	NS	NS	0.2	1.9	2.5	NS

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Irrigation Scheduling for Corn with Evapotranspiration Reports

F. R. Lamm

Summary

Corn was grown under nine different irrigation schedules, based on calculated water use and water use constraints. In the 3-year study, fully irrigated corn with a fertilizer rate of 210 lbs N/acre and a population of 23,000 plants/acre gave the highest net returns. The study did show there are opportunities to grow corn profitably with less than full irrigation, if fertilizer and plant populations are more closely matched to the irrigation constraint.

Introduction

Crop water use or evapotranspiration (ET) can be calculated on a daily basis from climatic data and crop growth stages. Research during the 1982-1984 period has shown the validity of using daily ET values in a simple water budget to schedule irrigation of corn. A new study from 1986 through 1988 involved special tailoring of resource inputs such as fertilizer, seed, and irrigation to meet expectations and/or constraints. Irrigators scheduling deficit irrigation should probably adjust fertilizer rates and plant population to minimize costs and to conserve natural resources. The objective of this study was to examine reasonable alternatives in terms of profitability and resource use.

Procedures

The study was conducted in a level basin with nine irrigation treatments replicated three times in plots 15' by 100'. Small borders separated each plot. Evapotranspiration was calculated by a modified Penman approach, with crop coefficients selected for the planting date of the study. The treatments were devised to examine several reasonable irrigation schemes within three given

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constraints on total irrigation water allowance. The schemes and assigned treatment numbers were as follows:

Water allowance not to exceed 18 inches total.

1. 100% of reported ET
2. 75% of reported ET
3. 50% of reported ET

Water allowance not to exceed 12 inches total.

4. 100% of reported ET
5. 75% during vegetative stage, 100% thereafter
6. 50% during vegetative stage, 100% thereafter

Water allowance not to exceed 6 inches.

7. 100% of reported ET
8. 75% during vegetative stage, 100% thereafter
9. 50% during vegetative stage, 100% thereafter

Irrigation water was metered into each plot according to the following plan:

1. Set allowable depletion at 3.0-4.0 inches.
2. Sum ET since last irrigation and multiply sum by treatment factor.
3. Subtract all precipitation since last irrigation.
4. Irrigate when summation was within allowable depletion range.

The maximum irrigation rate in the corn study was not allowed to exceed 0.30 inches/day or a 3-inch irrigation in a 10-day period. Tassel initiation was chosen as the point to shift from the initial ET factor to the final ET factor for treatments 5, 6, 8, and 9. Different fertilizer rates and plant populations were used with the different irrigation schemes to minimize production costs. Treatments with an initial ET factor of 100% received a fertilizer rate of 210 lbs. N/a and were planted to a population of 23,000 p/a. The 75% ET factor (initially) treatments received 180 lbs. N/a and had a plant population of 20,900 p/a. Those treatments scheduled with an initial ET factor of 50% received 150 lbs. N/a and were planted to 17,100 p/a. The corn (Pioneer 3377) was planted on April 27, 1988.

A sample from each plot was harvested in the fall for yield determinations.

Economic analysis of the treatments was made by comparing the costs of the three changing input resources--irrigation, fertilizer, and seed. All additional input costs such as labor, pesticides, and harvesting costs were held constant at $120.

Results and Discussion

In 1988, yields ranged from a low of 63 bu/a for treatment 3 to a high of 157 bu/a for treatment 1 (Table 1). High evapotranspiration and low rainfall during June had a detrimental effect on early crop development and, as a result, lowered yields for all treatments except the fully irrigated treatment (1).

Yields for treatments receiving 6 inches of irrigation ranged from 63 to 102 bu/a. Under this severe constraint, highest yields were obtained when the limited amount of irrigation was shifted toward the critical reproductive stages (treatments 8 and 9).

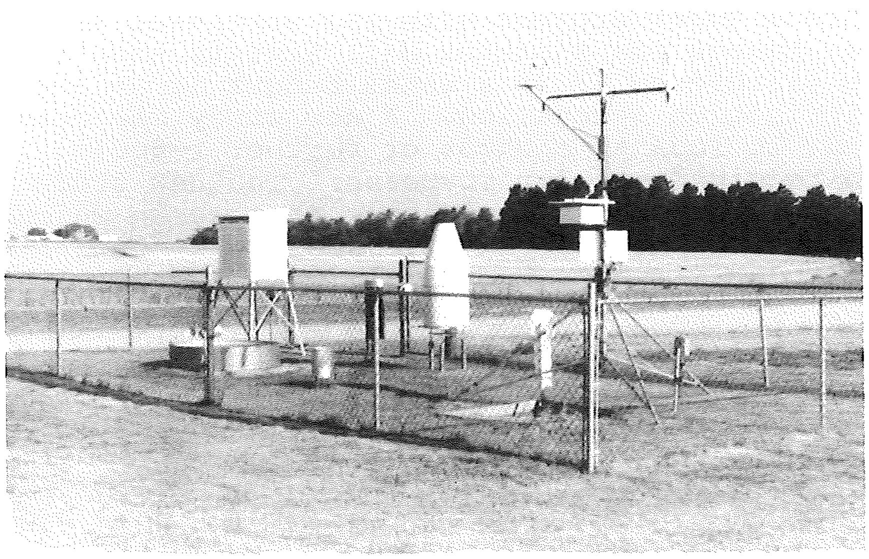
The highest net returns were obtained by treatments 1 and 5. During the first two years of the study, treatment 5 on the average had the highest net returns. This shows that, at least in some years, a reduction in irrigation during the vegetative stage can result in higher net returns, when other resources are properly balanced. An analysis of treatments 7, 8, and 9 shows a good example of how input resources can be managed to maximize net returns. Though all three treatments received 6 inches of irrigation, the net returns are appreciably higher for treatments 8 and 9 for which fertilizer and seeding rates were matched closer to the constraint on irrigation. It is also apparent that subjecting the crop to water stress during the entire season (treatments 2 and 3) is less desirable than stress applied only during the vegetative period (treatments 4 and 5 or 8 and 9).

Results from this study indicate that proper matching of input resources can result in profitable scenarios at less than maximum yields.

Table 1. Economic analysis of management practices and their effects on corn yields in an irrigation scheduling study, KSU Northwest Research-Extension Center, 1986-88.

Trt. no.	ET factor	Irrigation constraint	Fert. rate	Plant pop.	Irrigation 1986	Irrigation 1987	Irrigation 1988	Irrigation Mean	Yield 1986	Yield 1987	Yield 1988	Yield Mean	Net returns[1] 1986	Net returns[1] 1987	Net returns[1] 1988	Net returns[1] Mean
		inches	lb N/a	p/a	------inches			-------	--------bu/a			-------	--------- $			---------
1	1.00ET	18	210	23000	15	12	18	15	159	161	157	159	186	202	171	186
2	0.75ET	18	180	20900	9	9	12	10	154	121	125	133	200	116	116	144
3	0.50ET	18	150	17100	3	3	6	4	125	102	63	97	154	96	-14	79
4	1.00ET	12	210	23000	12	12	12	12	169	147	120	145	222	166	97	162
5	0.75/1.00ET	12	180	20900	12	9	12	11	162	152	127	147	210	195	121	175
6	0.50/1.00ET	12	150	17100	9	9	12	10	147	143	125	138	189	179	123	164
7	1.00ET	6	210	23000	6	6	6	6	123	112	63	99	126	98	-27	66
8	0.75/1.00ET	6	180	20900	6	6	6	6	139	136	74	116	172	165	7	115
9	0.50/1.00ET	6	150	17100	6	6	6	6	139	120	102	120	179	131	85	132

[1] Budget analysis based on different costs of fertilizer, seed and irrigation for the various treatments. Prices assumed were nitrogen fertilizer at $0.12/lb, seed at $70/bag with 75,000 seeds/bag, irrigation pumping costs of $3.50/acre-in, other fixed and variable costs of $120, and corn at $2.55/bu.



Automated and NOAA weather stations at the KSU Northwest Research-Extension Center, 1988.

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Irrigation Scheduling of Soybeans with Evapotranspiration Reports

F. R. Lamm

Summary

Imposing a moderate amount of water stress on soybeans during the vegetative period can reduce irrigation requirements while maintaining yields. In extreme years such as 1988, the irrigator should alter the irrigation schedule to alleviate severe water stress during the vegetative period.

Introduction

The KSU Northwest Research-Extension Center has been reporting daily calculated evapotranspiration (ET) values for soybeans for farmers to use in a water budget for irrigation scheduling, similar to balancing a checkbook. In 1982, the KSU Northwest Research-Extension Center entered into a joint project with the Northwest Kansas Groundwater Management District #4. Results have shown that using calculated ET in a water budget is an acceptable means of irrigation scheduling. A new study was conducted from 1986-88 to look at methods of further reducing irrigation requirements for soybeans. The new study compares previous scheduling schemes to ones in which water is limited during the soybean's vegetative stage.

Procedures

Soybeans (S Brand 58-A, planted 5-11-88) were grown in a level basin, subdivided into plots (100 x 15 ft.), with treatments replicated three times in a completely randomized block design.

Crop water use (ET) was calculated using a modified Penman equation. Irrigation water was metered into each plot according to the following plan:

1. Set allowable depletion at 3.0-4.0 inches.
2. Sum ET since last irrigation and multiply sum by treatment factor.
3. Subtract all precipitation since last irrigation.
4. Irrigate when summation is within allowable depletion range.

The irrigation treatments were as follows:

1. 100% of reported ET (Standard)
2. 75% of reported ET
3. 50% of reported ET
4. No irrigation
5. 50/100% of reported ET
6. 75/100% of reported ET

where treatments 5 and 6, respectively, received only 50 and 75% of the ET requirements during the vegetative period and 100% during the reproductive stage. Treatments 5 and 6 were shifted to the higher irrigation level on July 20, 1988. The range of treatments allows for examining the effects of full-season and vegetative-period stress on yields as compared to a 100% of ET standard treatment and a nonirrigated control.

A sample from each plot was harvested in the fall (10-01-88) for yield determinations.

Results and Discussion

Climatic conditions during the summer of 1988 resulted in an irrigation requirement of 12.7 inches for the fully irrigated treatment. Extremely high evapotranspiration and low rainfall imposed considerable water stress on the soybeans during the early-vegetative, developmental period.

In 1988, soybean yields were significantly higher for the fully irrigated treatment (Table 1). This is in contrast to the results for 1986 and 1987 (Table 2), in which yields for treatments 2, 5, and 6 showed that soybeans can be partially water stressed and still yield well.

There were significant differences in seed weight, seeds/pod, and pods/plant, with treatments 1, 2, and 5 having respectable values in all three areas. Highest water use efficiency was obtained with treatment 1 because of the significantly higher yield.

During the 3-year study, the irrigation requirement for the fully irrigated treatment averaged 13.1 inches (Table 2). However, additional water savings were possible by imposing moderate water stress on the soybeans during the vegetative period with little reduction in yield. In extreme years such as 1988, the irrigator should alter the irrigation schedule to alleviate the severe early-season water stress.

Table 1. Summary of soybean yield components and water use data from a climate-based irrigation scheduling study, KSU Northwest Research Extension Center, 1988.

ET factor	Plant characteristics			Seed wt.	Grain yield	Irrigation	Water use	WUE[1]
	Plants /acre	Pods/ plant	Seeds /pod	gm/100	bu/acre	-----inches-----		lbs/a-in
1.00	116,160	40.2	2.05	19.02	64.4	12.65	26.0	149
0.75	110,352	35.2	2.11	18.19	54.3	9.77	24.5	133
0.50	91,040	36.3	1.55	17.64	32.2	3.15	18.7	103
No Irr	123,855	21.8	1.28	17.20	21.7	0.00	14.7	88
0.75/1.00	104,544	30.5	2.57	18.53	55.6	12.52	24.8	135
0.50/1.00	120,080	23.7	1.97	22.53	42.9	10.25	20.2	127
Mean	111,005	31.3	1.92	18.85	45.2	-----	21.5	123
LSD (.05)	NS	8.9	0.49	1.19	9.9	-----	1.4	23

[1] Water use efficiency is defined as yield in lbs/acre divided by total water use in inches.

Table 2. Summary of soybean yield and water use data from a climate-based irrigation scheduling study, KSU Northwest Research-Extension Center, 1986-1988.

Irrigation Trt. (ET Factor)	Net irrigation 1986	1987	1988	Mean	Water use 1986	1987	1988	Mean	Grain yield 1986	1987	1988	Mean	WUE[1] 1986	1987	1988	Mean
	------inches-------				------inches-------				----bushels/acre---				---lbs/acre-inch---			
1.00 (Standard)	15.5	11.1	12.7	13.1	25.6	23.7	26.0	25.1	57.7	49.7	64.4	57.3	135	126	149	137
0.75	10.2	7.2	9.8	9.1	22.1	20.1	24.5	22.2	56.4	48.2	54.3	53.0	152	145	133	143
0.50	3.6	3.5	3.2	3.4	16.9	17.0	18.7	17.5	39.9	40.3	32.2	37.5	142	142	103	129
No Irrigation	0.0	0.0	0.0	0.0	14.0	14.7	14.7	14.5	26.3	29.0	21.7	25.7	113	120	88	107
0.75/1.00	10.8	11.4	12.5	11.6	21.5	24.0	24.8	23.4	59.7	48.5	55.6	54.6	166	121	135	141
0.50/1.00	10.4	9.9	10.3	10.2	21.4	22.2	20.2	21.3	59.5	51.7	42.9	51.4	167	139	127	144
Mean	8.4	7.2	8.1	7.9	20.3	20.3	21.5	20.7	49.9	44.6	45.2	46.6	146	132	123	134
LSD (.05)	----	----	----	----	1.0	0.9	1.4	----	10.7	5.3	9.9	----	29	23	23	----

[1]Water use efficiency is defined as pound of grain yield/acre divided by inches of total water used.

Irrigation Scheduling of Sunflowers with Evapotranspiration Reports

F. R. Lamm

Summary

Irrigated sunflower yields were excellent in 1988. The standard treatment (100% of ET) with an irrigation amount of 9.9 inches yielded 3,328 lbs/acre. Further research is warranted in evaluating sunflower response to irrigation because of the poor yields in 1986 and 1987.

Introduction

The KSU Northwest Research-Extension Center has been reporting daily calculated evapotranspiration (ET) values for several crops for farmers to use in a water budget for irrigation scheduling, similar to balancing a checkbook. Because of increased interest in sunflowers as an alternative irrigated crop, the KSU Northwest Research-Extension Center developed a project with the Northwest Kansas Groundwater Management District #4 in 1986 to develop and evaluate irrigation scheduling techniques for sunflowers. The results of this 3-year study are presented here.

Procedures

Sunflowers (Triumph 500) were planted on June 13, 1988 at 25,600 plants/acre. The sunflowers were grown in a level basin, subdivided into plots (100 x 15 ft.), with treatments replicated three times in a completely randomized block design.

Crop water use (ET) was calculated using a modified Penman equation. Irrigation water was metered into each plot according to the following plan:

1. Set allowable depletion at 3.0-4.0 inches.
2. Sum ET since last irrigation and multiply sum by treatment factor.
3. Subtract all precipitation since last irrigation.
4. Irrigate when summation is within allowable depletion range.

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The irrigation treatments were as follows:

1. 140% of reported ET
2. 120% of reported ET
3. 100% of reported ET (Standard)
4. 75% of reported ET
5. 50% of reported ET
6. No irrigation

Each plot was instrumented with an access tube for neutron probe measurements of soil moisture. Measurements were made on an approximately weekly basis in increments of 1 foot to a depth of 5 ft. These measurements were made to compare actual water use to the calculated ET values.

A sample from each plot was harvested in the fall (9-24-88) for yield determinations.

Results and Discussion

Climatic conditions during the summer of 1988 resulted in an irrigation requirement of 9.9 inches for the fully irrigated standard (100% of ET) treatment. Sunflowers planted in mid-June missed much of the adverse hot, dry weather conditions that affected crops such as corn and soybeans.

There were significant differences in yields between treatments ranging from 2,568 to 3,759 lbs/acre for the non-irrigated and heavily-irrigated treatments, respectively (Table 1). Treatment 1, which had the highest yield, required 16.55 inches of irrigation. This level of irrigation (140% of ET) is not very practical for most irrigators in northwest Kansas, because it requires considerable system capacity to meet the needs during the critical growth stages.

Yields were excellent in 1988 compared to the low yields in 1986 and 1987 (Table 2). Yields in 1987 were extremely low (mean yield 1,318 lb/acre) because of leaf diseases that caused early senescence. Because of the poor response of sunflowers to irrigation in two of the three years of the study, further research is warranted.

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Table 1. Summary of sunflower yield components and water use data from an irrigation scheduling study, KSU Northwest Research Extension Center, 1988.

ET factor	Plant characteristics			Grain[1] yield	Irr.	Water use	WUE[2]
	Heads /acre	Seeds /head	gm/100 seeds	lbs./ acre	---inches---		lbs./ a-in
1.40	16552	1528	6.84	3759	16.55	27.5	137
1.20	16553	1326	7.22	3015	13.35	24.8	121
1.00	19166	1285	6.23	3328	9.90	23.0	145
0.75	18585	1258	6.09	3065	6.10	19.6	157
0.50	18005	1388	5.89	2998	3.10	18.4	163
No Irr.	21780	1013	5.29	2568	0.00	15.4	167
Mean	18440	1300	6.26	3122	-----	21.4	148
LSD (.05)	NS	NS	NS	612	-----	1.9	25

[1] Adjusted to 12.5% moisture content
[2] Water use efficiency is defined as yield in lb/acre divided by total water use in inches.

Table 2. Summary of sunflower yield and water use data from a irrigation scheduling study, KSU Northwest Research-Extension Center, 1986-1988.

ET factor	Grain yield 1986	Grain yield 1987	Grain yield 1988	Grain yield Mean	Water use 1986	Water use 1987	Water use 1988	Water use Mean	WUE[1] 1986	WUE[1] 1987	WUE[1] 1988	WUE[1] Mean
	------lb/acre------				-------inches------				------lbs/a-in-----			
1.40	2385	1365	3759	2503	23.3	25.9	27.5	24.6	103	53	137	78
1.20	2279	1534	3015	2276	21.4	23.1	24.8	22.3	106	66	121	86
1.00	2402	1385	3328	2372	18.5	21.9	23.0	20.2	130	63	145	97
0.75	2432	1341	3065	2279	16.2	19.6	19.6	17.9	151	69	157	110
0.50	2292	1117	2998	2136	13.6	15.3	18.4	14.5	170	73	163	122
No Irrigation	2328	1165	2568	2020	11.4	13.6	15.4	12.5	204	86	167	145
Mean	2353	1318	3122	2264	17.4	19.9	21.5	18.7	144	68	148	106
LSD (.05)	NS	NS	612	----	1.2	1.1	1.9	----	30	NS	25	----

[1] Water use efficiency is defined as yield in lbs/acre divided by total water use in inches.

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Interactions of Irrigation and N Rate on a Rotation of Fertilized Corn and Unfertilized Soybeans

H. D. Sunderman

Summary

A corn-soybean rotation was grown under three irrigation regimes imposed on each crop and five N rates applied only to the corn during the period from 1985 through 1987. In 1988, the Keith silt loam site was uniformly irrigated, fertilized (80 lbs. N/acre), and cropped to corn. Averaged over all other treatment combinations, corn-following-soybeans outyielded corn-following-corn by 60 bushels/acre in 1988. This difference was much larger than normally expected and can be attributed partially to differences in stand establishment conditions. The portion of the field that had been in soybeans during 1987 was more mellow and impeded emergence less than the portion that had been in corn. Yields of corn-following-corn increased with increasing N rates applied in 1987. Although greater, yields of corn-following-soybeans were not influenced by previous N treatments.

This experiment will be terminated and cropped to irrigated grain sorghum in 1989 and thereafter under ridge-till until the site is suitable for research plots again. The site will be used in 1989 to evaluate a seed-furrow-applied polymer that possesses extremely high water-holding capacity.

Introduction

In anticipation of problems that would result from declining groundwater supplies and increasing pumping costs, we began several experiments to examine production alternatives. The one reported here was initiated in 1977 with the objective to determine the nitrogen fertilizer requirements of continuous corn under optimum, medium, and limited irrigation. Results showed that the fertilizer rate required for optimum yield under full irrigation was only slightly greater than that required under a lesser irrigation regime.

In 1980, the study was redesigned to a system in which most of the inputs were allocated to corn on a portion of the land, while the remainder was cropped less intensively

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with an unfertilized alternative. Initially, corn was chosen to be intensively cropped and grain sorghum was the alternative crop. Because both corn and grain sorghum share several common weed problems and common herbicides, weed control was sometimes difficult with this rotation, and the unfertilized grain sorghum performed poorly. In 1984, soybeans were substituted for grain sorghum to break the herbicide/weed cycle and to evaluate a crop that could provide part of its own nitrogen requirement.

Procedures

After the 1987 corn harvest, the stalks were chopped, and the site was disked and bedded. The soybean stalks were shredded, but the beds were merely reshaped rather than disking them down and starting from scratch. A preseason irrigation was applied on October 28. The site was treated with atrazine and Lasso herbicides on April 12, 1988 and planted with Lynks LX4355 at 28880 seeds/acre on April 21. Atrazine and Lasso were banded over the row at planting, and the plots were cultivated once on May 12. The furrows were formed, and 80 lbs. N/acre was sidedressed in a single operation on June 8. Five seasonal irrigations were applied, and the plots were machine harvested on October 10.

Results and Discussion

From the very beginning of the season, there was a marked difference between corn-following-corn (C-C) and corn-following-soybeans (C-SB). A 2-inch rain during emergence caused the soil to puddle and form a dense crust. This condition was worse on the C-C ground and resulted in a smaller plant population than on the C-SB ground. Throughout the season, the C-C plants were poorer in appearance than were the C-SB plants.

Averaged over all other treatment combinations, C-SB outyielded C-C by 60 bushels/acre (Table 1). This difference was much larger than normally expected and can be attributed partially to differences in stand establishment conditions. The portion of the field that had been in soybeans during 1987 was more mellow and impeded emergence less than the portion that had been in corn. Yield of C-C increased with increasing N rates applied in 1987. Although greater, yield of C-SB were not influenced by previous N treatments.

General conclusions would be 1) the concept provides a good alternative in those situations where the water supply or expense limit the area that can be irrigated at an optimum rate, 2) a corn-soybean rotation is preferable to a corn-sorghum rotation because of relative weed control problems, and 3) soybeans offer the opportunity to reduce corn production costs because less tillage is required to prepare the seed bed and because of reduced weed pressures.

This experiment was terminated at the end of the 1988 season, and the site will be cropped uniformly until differences will no longer affect future experiments. The site will be used in 1989 to evaluate grain sorghum production in a furrow-irrigated ridge-till system with a seed-furrow-applied polymer. The polymer has an extremely high capacity to hold water that may translate to several agronomic advantages.

Joe B. Kuska pulling soil samples in 1915
(second year after establishing the
Colby Branch Experiment Station).

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Table 1. Grain yields from a rotation of fertilized corn and unfertilized soybeans as influenced by N rate and irrigation regime, NWREC, 1985-88.

Irrigation[1] regime	N rate[2]	Corn grain yield 1985	Corn 1986	Corn 1987	Corn Mean	Corn 1988[3]	Corn 1988[4]	Soybean grain yield 1985	Soybean 1986	Soybean 1987	Soybean Mean
	lbs./A	bu.[5]/acre									
Limited	0	113	102	126	114	97	178	34	48	24	35
	50	120	101	122	114	119	172	37	48	21	35
	100	124	78	125	109	111	182	36	51	20	36
	150	131	82	113	109	117	182	33	51	19	34
	200	134	83	122	113	131	193	44	48	16	36
	250	142	83	91	105	144	188	37	45	21	34
	Mean	127	88	116	110	120	183	37	49	20	35
Medium	0	133	138	149	140	88	177	36	52	50	46
	50	160	126	168	151	94	166	42	55	50	49
	100	163	151	172	162	105	171	46	59	56	54
	150	157	130	175	154	116	175	40	58	46	48
	200	160	109	167	146	139	166	40	59	47	49
	250	160	133	169	154	144	187	43	58	50	50
	Mean	156	131	167	151	114	174	41	57	50	49
Full	0	137	155	176	156	91	172	29	48	39	39
	50	176	153	196	175	104	187	38	46	34	39
	100	184	176	202	187	139	195	44	52	41	46
	150	188	183	202	191	133	188	42	53	41	45
	200	196	173	202	190	146	190	46	51	40	46
	250	182	157	197	179	159	188	49	55	37	47
	Mean	178	166	196	180	129	187	41	51	39	44
Mean for N Rate:	0	128	131	150	136	92	175	33	49	38	40
	50	152	126	162	147	105	175	39	50	35	41
	100	157	135	166	153	118	183	42	53	39	45
	150	159	132	163	151	122	182	38	54	35	42
	200	163	122	164	150	138	183	43	53	34	43
	250	161	124	152	146	149	188	43	53	36	44

Source of variation	LSD (.05)									
Irrigation	10	30	10	--	9		3	NS	11	--
N Rate	5	NS	10[6]	--	NS		4	NS	NS	--
I x NR	8	21	17[6]	--	NS		NS	NS	NS	--

[1] In general, equivalent to 1, 3, or 5 furrow irrigations, respectively, per growing season.

[2] Rate applied to corn each year from 1985 thru 1987; 80 lbs. N/acre sidedressed on all plots in 1988. For soybeans, the rate refers to that applied to the preceding corn crop.

[3] Full irrigation and following 1987 fertilized corn.

[4] Full irrigation and following 1987 unfertilized soybeans.

[5] Adjusted to 56 lbs./bu. and 15.5% (corn) or 13.0% (soybeans) moisture.

[6] Significant at the 10 but not the 5 percent level.

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Relay Cropping of Soybeans into Wheat

F. R. Lamm

Summary

Research on relay cropping was initiated in 1979 at the KSU Northwest Research-Extension Center. The results obtained since that time have been highly variable, ranging from excellent crop yields to complete crop failure. Information on cultural practices for relay cropping is extremely limited. Results from earlier studies have indicated that selection of proper herbicides and soybean varieties is important in successful use of this cropping system. Results from 1987 and 1988 using granular herbicides and common soybean varieties are presented here.

Introduction

Climatic factors in northwestern Kansas make conventional double cropping after wheat difficult. For double cropping of grains to be feasible, a relay intercropping system, in which one crop is seeded before the other is harvested, will probably be needed.

Relay cropping, in which two or more crops are growing together at the same time, is not a new concept. It is still used extensively in countries where hand labor is a major component of agriculture. In the United States, there are two basic types of relay cropping. In one method, mechanical planters are used while trying to minimize crop damage, and in the other, a crop is seeded by aircraft into the existing crop.

Procedures

In 1987 and 1988, two studies were conducted to further develop the practice of interseeding soybeans into growing wheat. The objectives of the studies were to evaluate: 1) possible herbicides for weed control in the soybeans and 2) performance of various soybean varieties in a relay cropping system. Procedures for the 1988 study

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will be discussed here. In 1987, similar procedures were employed, and exceptions will be noted.

The wheat was fertilized with 190 lbs. N/acre as ammonium nitrate before drilling. A short stature wheat variety (Colt in 1987 and Pony in 1986) was used in the study to avoid excess height at harvest. The wheat was planted on September 18, 1987 at a rate of 60 lbs/acre.

In both 1987 and 1988, soybeans were mechanically interseeded into solid-seeded and skip-row seeded wheat. In the skip-row area, one of every three wheat rows was left blank at seeding, and the seeding rate was adjusted to approximately 60 lbs/acre, similar to the solid-seeded wheat. The skip-row pattern of one blank row with two seeded rows on a 10-inch spacing leaves gaps centered on 30 inches. In this case, 66% of the land area was planted compared to solid-seeded wheat. These blank rows provided a traffic way for planting, as well as extra light for the interseeded crop. In the herbicide study, soybeans were only interseeded into skip-row planted wheat.

The plots were interseeded on May 10, 1988 using a tractor-mounted, five-row planter for 30-inch soybean rows. John Deere 71 Flex-planters with double-disk openers were offset mounted on a double tool bar, such that two planters followed the tractor wheels to minimize damage to the growing wheat. In the case of solid-stand wheat, there would still be considerable damage to the growing wheat in most years. In the skip-row plots, 12 inch spin-sweeps were mounted on the front toolbar to cultivate weeds and to also loosen the soil following the tractor wheel.

A set of conventional, monoculture soybean plots (Williams 82 variety) was planted on May 13, 1988 in an adjacent field for comparison. Prowl herbicide at the rate of 2 pt/a was applied preplant incorporated to these plots on May 11, 1988.

Because of herbicide safety and performance problems in previous studies, granular herbicides were evaluated in 1987 and 1988. All herbicides were applied at planting in a 14-inch strip centered on the soybean row. Herbicide treatments for the two studies are shown in Table 1. **The herbicide combinations used are not currently labeled for use in Kansas for relay cropping. Read the product label before applying agricultural pesticides. Pesticide use inconsistent with the label may result in violation of federal law.** Additionally, in the 1988 herbicide study, a contact herbicide (Buctril 1.5 pt/a) was band applied to the skipped row to help control existing weeds. Both studies were sprayed with Scepter, at 0.5 pt/a on July 18, 1988 to help control pigweed and kochia.

Table 1. Herbicides and application rates band-applied at planting (5-10-88) in wheat-soybean relay cropping studies, KSU Northwest Research-Extension Center.

Experiment	Herbicide	Granular application rate
		lb./acre
Herbicide	1. No Herbicide	-
	2. Treflan 10G	4.7
	3. Treflan 10G	9.4
	4. Dual 25G	3.7
	5. Dual 25G	7.4
	6. Lasso II	9.3
	7. Lasso II	18.6
Varietal	Dual 25G	3.7

In the soybean varietal study, seven varieties of soybeans were tested--Williams 82, Douglas, Harper, Pella, Asgrow 3127, NC+ 2J96, and NC+ 2D90. In the herbicide test, Williams 82 was the variety used.

Wheat samples were harvested from each of the plots with a small plot harvester on July 1, 1988 for yield determination. After wheat harvest, interseeded areas were fertilized with 40 lbs N/acre in the form of broadcast ammonium nitrate.

Irrigation was scheduled by a water budget using calculated water use for the soybeans and was applied by a center pivot sprinkler.

Results and Discussion

In 1988, there was a severe loss of seedling soybeans in the solid-seeded wheat because of water stress. The rapidly growing wheat was drawing water from the surface soil layers faster than most center pivots could provide irrigation on a field basis. The small root system of the soybeans could not provide all the water needs of the seedling plants. Seedling loss from water stress had not been a major problem in other years, but it can occur, and fields need to be monitored. It should be pointed out that evapotranspiration for June was extremely high, and rainfall was very low. Though soybean seedling losses in the solid-seeded wheat were severe to the point of crop failure, there was little seedling loss in the skip-row wheat.

In 1988, there were no statistically significant differences (P=0.05) in wheat yields as affected by herbicide treatment in the herbicide study (Table 2). However, there were significant differences (Table 3) in the varietal study, with the skip-row pattern yielding only 92% as much as the solid-seeded wheat. Wheat planted in the skip-row pattern generally gives lower yields, usually 70-80% that of solid-seeded wheat.

Table 2. Yield of wheat and soybeans as affected by herbicide in a sprinkler irrigated, relay cropping experiment, KSU Northwest Research-Extension Center, 1987-1988.

	Wheat yield			Soybean yield		
Granular herbicide treatment	1987	1988	Mean	1987	1988	Mean
	bu/a					
No contact herbicide						
1A. Control - No herbicide	39.1	41.9	40.0	35.0	42.1	38.6
2A. Treflan 10G, 4.7 lb/a	46.1	43.3	44.8	32.3	47.8	40.1
3A. Treflan 10G, 9.4 lb/a	46.2	39.1	42.7	33.9	39.7	36.8
4A. Dual 25G, 3.7 lb/a	45.3	42.1	43.7	39.8	40.4	40.1
5A. Dual 25G, 7.4 lb/a	45.9	40.5	43.2	33.4	38.7	36.1
6A. Lasso II, 9.3 lb/a	40.7	42.0	41.4	34.2	44.2	39.2
7A. Lasso II, 18.6 lb/a	45.3	43.1	44.2	34.7	44.5	39.6
Contact herbicide (Buctril)						
1B. Control - No herbicide	----	40.1	----	----	44.0	----
2B. Treflan 10G, 4.7 lb/a	----	40.3	----	----	40.9	----
3B. Treflan 10G, 9.4 lb/a	----	41.5	----	----	43.2	----
4B. Dual 25G, 3.7 lb/a	----	42.4	----	----	46.1	----
5B. Dual 25G, 7.4 lb/a	----	43.9	----	----	41.9	----
6B. Lasso II, 9.3 lb/a	----	41.5	----	----	42.8	----
7B. Lasso II, 18.6 lb/a	----	39.7	----	----	37.7	----
Mean	44.1	41.5	42.8	34.8	42.4	38.6
LSD (.05) (Contact herbicide)	--	NS	--	--	NS	--
LSD (.05) (Granular herbicide)	NS	NS	--	4.0	NS	--

Table 3. Yield of wheat and soybeans as affected by wheat planting method and soybean variety in a sprinkler irrigated, relay cropping experiment, KSU Northwest Research-Extension Center, 1987-1988.

Wheat planting method	Soybean variety	Wheat yield 1987	Wheat yield 1988	Wheat yield Mean	Soybean yield 1987	Soybean yield 1988	Soybean yield Mean
		bu/a					
Solid-Seeded	Williams 82	57.9	44.2	51.1	33.1	40.3	36.7
	Douglas	59.2	43.7	51.5	39.5	30.6	35.1
	Harper	55.8	48.1	52.0	19.9	32.4	26.2
	Pella	57.8	44.6	51.2	26.0	31.3	28.7
	Asgrow 3127	55.2	42.4	48.8	24.2	24.0	24.1
	NC+ 2J96	58.0	48.1	53.1	35.4	24.2	29.8
	NC+ 2D90	53.2	45.8	49.5	23.3	21.5	22.4
Skip-row	Williams 82	51.6	40.6	46.1	34.2	47.7	41.0
	Douglas	52.2	39.8	46.0	40.0	40.2	40.1
	Harper	50.2	41.1	45.7	27.9	44.6	36.3
	Pella	50.1	45.2	47.8	43.9	44.1	44.0
	Asgrow 3127	46.8	42.4	44.6	30.9	39.4	35.2
	NC+ 2J96	47.0	39.7	43.4	31.1	42.1	36.6
	NC+ 2D90	48.8	41.3	45.1	28.2	42.5	35.4
Planting Means							
Solid-seeded		56.7	45.3	51.0	28.8	29.2	29.0
Skip-Row		49.5	41.5	45.5	33.8	42.9	38.4
Mean		53.1	43.4	48.3	31.3	36.1	33.7
LSD (.05)		NS	2.9	----	NS	8.9	----
Variety Means							
Williams 82		54.8	42.4	48.6	33.7	44.0	38.9
Douglas		55.7	41.7	48.7	39.8	35.4	37.6
Harper		53.0	44.6	48.8	23.9	38.5	31.2
Pella		54.0	44.9	49.5	35.0	37.7	36.4
Asgrow 3127		51.0	42.4	46.7	27.5	31.7	29.6
NC+ 2J96		52.5	43.9	48.2	33.2	33.2	33.2
NC+ 2D90		51.0	43.6	47.3	25.8	32.0	28.9
Mean		53.1	43.4	48.3	31.3	36.1	33.7
LSD (.05)		NS	NS	----	8.1	NS	----

In 1988, there were no statistically significant herbicide effects on soybean yield attributable to either the contact or granular herbicides (Table 2). It is somewhat surprising that the control (no herbicide) treatment yielded so well. However, the Scepter at 0.5 pt/a, applied as a blanket treatment on July 18, 1988 to all the plot areas, helped considerably in weed control. Russian thistles in the control plots would have presented problems in mechanical harvest, even though they did not significantly reduce yield. In 1987, all plots were cultivated once after wheat harvest, which did help reduce weed pressure.

Yields from soybeans interseeded into skip-row planted wheat were significantly higher than those from soybeans planted in the solid-seeded wheat in 1988 (Table 3). In fact, in a field situation, the soybeans planted in the solid-seeded wheat would probably have been destroyed after wheat harvest because of the extreme variability in stands. In addition, the soybeans interseeded into the skip-row planted wheat matured earlier, remained more upright, and were easier to machine harvest. There were no significant differences in yields between soybean varieties in 1988. Williams 82, on the average, performs well in a relay cropping situation. Pella performed well in the skip-row wheat but performed poorly in the solid-seeded wheat in both years.

Soybeans grown in the monoculture plots yielded 57.0 bu/a in 1988. Yields in the relay cropping system were good in relation to that figure. However, relay crop soybean yields have varied from total failure to excellent over the years.

Studies to date have indicated that best results are obtained by mechanically interseeding soybeans into skip-row planted wheat. Care must be taken in selecting soybean varieties, to avoid early maturing, prostrate-type varieties. Weed control continues to be a problem, but progress is being made.

Varying Date and Rate of Planting Irrigated Corn under High Fertility Conditions

H. D. Sunderman

Summary

To test the hypothesis that modern hybrids might produce higher yields from earlier planting under high soil fertility levels, an experiment was initiated on a Keith silt loam soil at the Northwest Research-Extension Center in 1985. Soil fertility at the site had been built to very high levels in previous experiments and was maintained at currently acceptable rates. Experimental variables were corn hybrid, planting date, and seed spacing. Averaged over all other variables, the 4-year average showed 1) a 3-bushel advantage for planting 10 days earlier than the average last spring freeze date, 2) a 7-bushel advantage for hybrid selection, and 3) an 18- to 6-bushel advantage for decreasing the seed spacing from 8 or 7 to 6 inches (approximately 26,100, 29,900, and 34,800 seeds/acre, respectively).

To effectively use such inputs, key considerations would include 1) selecting hybrids that will respond positively to early planting and higher populations, 2) adopting an approach of building to higher yield levels rather than attempting to make a major jump in one season, 3) conducting small-area, on-farm trials to identify hybrids that will respond positively under local soil and management conditions, and 4) having a method (such as ridge-till) in place to control weeds and volunteer corn that emerge after early-planted corn.

Introduction

One approach to increasing corn yields is to either plant hybrids with the longest growing season requirement that will still allow them to safely reach maturity or increase the length of the growing season. To utilize hybrids with too long a growing season requirement, one can increase the length of the growing season by planting a little earlier on bedded soil. Planting on-the-bed is a key factor because soil in the seed zone often reaches germination temperatures a little earlier in bedded soil compared to a flat soil surface.

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Numerous experiments in northwestern Kansas over the years have failed to show an advantage to planting corn earlier than May 1. Since volunteer corn will generally appear by this date, it would seem that a portion of the growing season is often lost when planting is delayed to May 1 or later.

Another approach is to increase plant population to a point at which plant density is in balance with other production inputs. Since currently recommended planting dates were derived from studies conducted under conventional soil fertility levels and plant populations, this study was initiated to determine if the same recommendations would hold for an intensified corn production system.

Procedures

General Agronomics and Soil Fertility

The soil was a Keith silt loam that had been cropped to irrigated corn and grain sorghum under adequate soil fertility programs through 1979. After harvest in 1979, the program was altered to significantly increase its plant nutrient content, organic matter content, and water holding capacity. In 1985, the study was changed from one of hybrid screening to its present form.

The general approach has been to shred the stalks after harvest, apply half the nitrogen as urea-ammonium-nitrate solution (UAN) and all of any other nutrients broadcast, disk to incorporate the residue, bed, and apply a preseason furrow irrigation. The remaining nitrogen was applied in a late sidedress that also included a nitrification inhibitor. In-season irrigations were generally made in smaller amounts at slightly shorter intervals.

Corn Hybrids, Planting Dates, and Plant Populations

Two hybrids were selected from those evaluated in an earlier study. Both of these hybrids had demonstrated a potential for high yields but one tended to be resistant to lodging and one was susceptible.

In 1985 and 1986, the desired seed spacings were achieved by hand planting. In the next 2 years, the plots were planted with a Hiniker no-till machine, and seed spacings were achieved with a hydraulically controlled attachment. To obtain production-type information, seeds were placed in the desired spacing rather than over-planting and then thinning to the desired spacing. Likewise, all plots were machine harvested for grain yield without accounting for dropped ears.

Soybeans

In 1986, half of the experimental area was planted to soybeans at the expense of deleting the late corn planting date. In 1987 and 1988, the corn and soybeans were rotated, and a single soybean cultivar was planted with and without inoculation at rates of 6, 8, 10, and 12 seeds per foot of row (approximately 104, 139, 174, and 209 thousand seeds/acre, respectively).

Results and Discussion

1988 Corn

The average soil temperature at the first planting date (April 21) was 57F and, with fairly good germination and emergence conditions, seedlings began to emerge on May 3. A period of rainy and cold conditions delayed the second planting from May 2 to May 6, with emergence beginning on May 15. The average 4-inch soil temperature on May 6 was 55F.

Several periods of wet and cool conditions slowed growth in May, but above-normal temperatures in June accelerated growth. Plants from the first planting date began to tassel on July 8 and silk on July 13. These stages were reached about 5 days later by plants from the second planting date.

Plots were harvested as high-moisture grain on October 10. Lodging was not a problem at this time, which may be the reason that the lodging-susceptible hybrid performed better this season (Table 1). In other respects, previously observed trends continued, with the early planting outyielding the later and the higher populations outyielding the lower (Tables 1 and 2).

In 1989, the entire area of this experiment will be planted to corn using the same experimental variables, but with ridge-till rather than conventional tillage.

Table 1. Grain yields from lodging-resistant and lodging-susceptible corn hybrids planted in an intensified system on two dates and at three seed spacings, NWREC, 1985-89.

Planting date[1]	Hybrid lodging	Seed spacing[2]	Grain yield[3]				
			1985	1986	1987	1988	Mean
		inches	---------	bu./acre			---------
First	Resistant	5	216	216	186	219	209
		6	204	205	208	213	208
		7	211	226	200	201	210
		8	191	---	184	191	189
		Mean	205	216	195	206	204
	Susceptible	5	200	205	183	224	203
		6	189	205	186	222	200
		7	193	197	176	205	193
		8	184	---	167	186	179
		Mean	191	202	178	209	194
Second	Resistant	5	197	196	211	198	200
		6	194	207	213	210	206
		7	187	201	203	203	198
		8	164	---	181	198	181
		Mean	185	201	202	202	196
	Susceptible	5	211	196	187	202	199
		6	186	192	189	216	196
		7	196	196	194	204	198
		8	181	---	196	193	190
		Mean	193	195	192	204	196
Third	Resistant	5	154	187	---	---	
		6	177	204	---	---	
		7	150	194	---	---	
		8	157	---	---	---	
		Mean	159	195	---	---	
	Susceptible	5	146	190	---		
		6	156	196	---		
		7	152	185	---		
		8	150	---	---		
		Mean	151	191	---		

[1]1985:4/22, 5/6, and 5/20; 1986: 4/22, 5/2, and 5/13; 1987: 4/29, and 5/6.
[2]handplanted to spacing in 1985 and 1986; machine planted in 1987 and 1988.
[3]Adjusted to 15.5 percent moisture and 56 lbs./bu.

1988 Soybeans

The corn-soybean rotation was injected into this experiment to take advantage of the yield-enhancing properties of soybeans on corn. For the 2-year period of the test, the soybeans were grown where no soybeans had been grown before. Root nodules were small and, in 1988, didn't appear to be very active. It is assumed that much of the nitrogen nutrition was obtained from the soil. Even so, there was a tendency for inoculated to outyield non-inoculated seed (Table 3).

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Except for the 1987 treatment of 12 inoculated seeds per foot of row, highest grain yields were obtained with 10 seeds per foot (Table 3). This agrees with the KSU recommended rate for soybeans planted in 30-inch rows.

Table 2. Overall means for grain yields reported in Table 1.

Planting date	Hybrid lodging	Seed spacing	Grain yield				
			1985	1986	1987	1988	Mean
		inches	--------bu./acre--------				
First			198	209	186	208	200
Second			189	198	197	203	197
Third			155	193	---	---	---
	Resistant		183	204	198	204	197
	Susceptible		172	196	185	206	190
		5	187	198	192	211	197
		6	184	202	199	215	200
		7	181	200	193	203	194
		8	171	---	182	192	182
Year			184	200	195	205	196

Table 3. Grain yields of inoculated and non-inoculated soybeans at four seeding rates in 1987 and 1988.

Seed inoculation		Grain yield[1]				
		Seeding rate, seeds/foot of row				
		6	8	10	12	Mean
		------------- bu./acre --------------				
Yes	1987	56.6	63.5	65.1	69.0	63.6
	1988	56.2	60.7	62.6	62.3	60.5
	Mean	56.4	62.1	63.8	60.6	62.0
No	1987	50.0	55.0	57.8	55.3	54.5
	1988	58.1	61.2	63.4	61.8	61.1
	Mean	54.0	58.1	60.6	58.6	57.8
	Mean	55.2	60.1	62.2	59.6	59.9

[1] Adjusted to 13 percent moisture and 56 pounds/bushel.

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Tilt Fungicide Effects on Performance of Spring Barley and Spring Oats

J. R. Lawless

Summary

Tilt fungicide was ineffective in improving either yield or quality characteristics when foliarly applied to both spring barley and spring oats prior to heading in 1988. Potential improvements may have been masked by hot, dry conditions prior to maturation, which resulted in reduced yield and test weight values for both crops.

Introduction

Spring barley and spring oats are crops grown on limited acres annually in northwestern Kansas. Performance of both crops is quite variable, depending on environmental conditions existing within individual years. Favorable conditions would include adequate temperature and soil moisture conditions for early March planting, rapid emergence, and vigorous growth following planting, combined with the absence of disease throughout the season and mild temperatures as the crops near maturation. The lack of one or more of these conditions may result in reduced grain yield, quality, and value. Tilt fungicide has been effective at Colby and elsewhere in controlling certain foliar diseases of winter wheat and, thus, improving both yield and quality characteristics. The present investigation was designed to ascertain the potential for obtaining similar results with application of Tilt to spring oats and spring barley.

Procedures

Separate but adjacent tests were established for spring barley and oats on a Keith silt loam site on the Northwest Research-Extension Center. Split plot designs were used for each of the tests, with fungicide (Tilt or no Tilt) as the main plot variable and varieties as the split plot variable. Five oat and four barley varieties were included in tests planted on February 26. Tilt fungicide was applied on May 20 at the rate of 4 oz. material in solution with 20 gallons of water per acre. Both tests

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were harvested on July 2. Data were obtained for height, heading date, lodging, yield, and test weight.

Results and Discussion

Emergence was rapid, and growth was excellent throughout the spring. No serious disease problems developed. Hot, dry conditions in late June caused rapid maturation and resulted in reduced yields and poor test weight values. Analysis of variance data indicated only nonsignificant differences from fungicide application. Therefore, these data are not included. Similar investigations on the potential effects of fungicide application to spring oats, barley, and wheat are planned for 1989.

Irrigated wheat variety performance test,
KSU Northwest Research-Extension Center, 1988.

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Tilt, Imazalil, and Chloride Effects on Performanceof Spring-Planted Wheat

J. R. Lawless and H. D. Sunderman

Summary

Seed-applied imazalil and in-furrow potassium chloride appeared to enhance growth of spring-planted Larned wheat. NAPB Oslo and Guard wheats were less affected. Neither of the treatments alone or in combination with foliar-applied Tilt fungicide influenced wheat yield or seed quality. Response to treatment may have been masked by high temperatures and dry conditions during the grain filling period.

Introduction

Spring planting of wheat is not generally recommended in northwestern Kansas because of low yields and poor grain quality, but conditions occasionally exist to warrant the utilization of spring-planted wheat. Its poor performance is related to several factors including insufficient vernalization (for spring-planted winter wheat varieties), lack of tillering, foliar diseases, and high air temperatures during maturation. This experiment focused on the disease problem.

Imazalil is a seed-applied fungicide for controlling certain diseases. Chloride, a part of the fertilizer potassium chloride (KCl), has been found by researchers in the Pacific Northwest and the Dakotas to reduce the impact of certain wheat diseases. Tilt, a foliar-applied fungicide, has been effective in tests at Colby and elsewhere in alleviating certain foliar disease problems affecting winter wheat. This study was designed to determine the response of three spring-planted wheats to combinations of planting time treatments, either imazalil or KCl, and foliar-applied Tilt applications.

Procedures

The experiment was established on a Keith silt loam soil at the Northwest Research-Extension Center. A split-plot design was used with four replications. Main plot

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treatment was foliar-applied fungicide (yes or no). The sub-plot treatment was a complete factorial involving wheat variety and seed-applied treatments. Varieties were Guard and NAPB Oslo spring wheats and Larned winter wheat. Planting time treatments were either imazalil or KCl; there was an untreated control. Imazalil was applied to the seed at the rate of 8 oz./100 lbs. of seed prior to planting. KCl (20 lbs./acre) was applied with the seed at planting on February 26. Planting rate was 90 lbs. seed/acre. Tilt fungicide, 4 oz. material in solution with 20 gallon of water, was applied to the appropriate plots on May 20 at approximate growth stage 8 (Feeke's scale). Data on heading date, height, yield, test weight, and thousand kernel weights were obtained. The plots were visually inspected periodically to identify any differences related to treatment. The wheat was machine harvested on July 6.

Results and Discussion

Wheat emergence began in late March, and stands were complete by early April. Notes taken on April 11 and on June 3 indicated apparent differences from planting time treatments. Plots with either imazalil or KCl appeared to have slightly thicker stands and more vigorous growth than untreated plots. This effect was most apparent with the variety Larned.

High temperatures in late June and early July hastened maturity of all varieties and caused extreme reduction in both grain quantity and quality. Differences for both planting time and foliar treatment were nonsignificant ($P = 0.05$) for each of the characteristics measured. Because no significant effects were observed, data are not included.

Effects of Seed-Applied Imazalil on Winter Wheat

H. D. Sunderman

Summary

Seed applications of imazalil were compared with applications of Vitavax and no treatment of Newton wheat at three sites representing a range of cultural practices. Drouthy conditions during germination and emergence resulted in poor stands and caused the no-till site to be abandoned. High temperatures and drought from milk stage to harvest severely limited results from the other two irrigated sites. It is likely that such adversity would mask small, but normally significant, differences. Seed treatments produced neither visual responses nor changes in either grain yield or test weight at any reasonable level of significance. These experiments will be continued during the 1988-89 season.

Introduction

Seedling diseases are a fairly common cause of wheat not getting a good start toward optimum yields. Seed treatments are an economical and effective method for controlling or reducing the impact of certain common organisms affecting wheat. This experiment was begun to evaluate imazalil under field conditions in northwestern Kansas. Financial assistance and the product were provided by Janssen Pharmaseutica.

Procedures

Three representative sites of Keith silt loam were chosen to represent a range of wheat growing conditions. Site No. 1 was fully irrigated by a low-pressure, center pivot sprinkler system. It had been prepared for seeding by alternately disking and irrigating to decompose and incorporate wheat straw from the previous crop. Site No. 2 was on a leveled border that had been cropped to wheat in the previous season under flood irrigation. Site No. 3 had been in fallowed, no-till wheat production for eight years.

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Ammonium nitrate was broadcast with a Barber fertilizer spreader on September 9 to provide 120 pounds of nitrogen per acre on Site No. 1, 60 pounds on No. 2, and 45 pounds on No. 3.

The seed for this experiment was foundation-grade Newton that weighed 60.2 pounds per bushel and had a 1000-kernel weight of 32.1 grams. Seeds were treated with diluted imazalil (IMZ) at a rate equivalent to 0.5 fluid ounces in 15 ounces of solution per 100 pounds of seed. The seeds then were stirred and spread to dry. The same procedure was used to apply Vitavax for one control treatment. A second control consisted of seed treated only with water.

Experimental design was a randomized complete block with four replications. On September 21, all plots were seeded in the sequence of no treatment, Vitavax, and then IMZ. Seeding rates were 84 pounds per acre for site No. 1 and 53 pounds for the other two. Seeding depth was increased to about 2.5 inches because of dry conditions and to provide a more stringent test of the seed treatments.

The center eight rows of plots at sites No. 1 and 2 were machine harvested on June 28. Plot grain weights were determined with a load cell weighing system immediately after harvesting each plot. A subsample collected at that time was used to determine grain moisture and test weight.

Results and Discussion

Climatic Influence

As a consequence of drought, moisture was deficient in the seed zone of the dryland site (No. 3), and seeding operations were accompanied with considerable hope for rain. These rains did not occur. Final stands were too uneven for a valid experiment on this site, and it was abandoned in the spring.

Excellent seeding conditions and early plant development was achieved on the fully irrigated site No. 1. It was intended that Site No. 2 receive only an early preplant irrigation but one additional application was made on October 5 in a vain attempt to improve stands. Even with this irrigation, many fewer plants emerged than was desired, and these were late and did not tiller very well.

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Very high air temperatures during the late-milk stage severely damaged the grain. Even with a late irrigation on June 12, grain yields (Table 1) from the irrigated site were about 60 percent of normal. Although it appears that the late irrigation helped to reduce the adverse effects on test weight, values were still well below what can reasonably be expected from this site. The grain was generally fully developed but shriveled.

With a preplant irrigation and normal climatic conditions, we would have expected grain yields from site No. 2 to be in the range of from 50 to 60 bushels per acre. The low yields and low quality (Table 1) are attributed to the poor seeding and establishment conditions present in the fall and to the high temperatures and below-normal rainfall in June. Because of heat and moisture stress, seed from this site was much smaller than normal.

Seed Treatments

Throughout most of the growing season, plants at the irrigated site appeared to be developing normally, and there was little visual evidence of disease. Leaf rust appeared late in the season but probably had little, if any, effect on yield. No visual differences in plant emergence, growth, or development were observed among the treatments.

Although the adverse germination and emergence conditions experienced at the limited-irrigation site (No. 2) may have been a more stringent test of the seed treatments, no differences were observed (Table 1).

This experiment will be continued during the 1988-89 growing season.

Table 1. Responses of wheat to seed-applied imazalil and Vitavax, KSU Northwest Research-Extension Center, 1987-88 growing season.

Seed treatment	Grain yield[1]	Test weight	Moisture content
	bu./acre	lbs./bu.	%
Fully-irrigated, Site No. 1			
None	53.4	56.6	10.5
Vitavax	52.1	57.4	10.4
IMZ	53.2	57.4	10.8
Mean	52.9	57.1	10.6
Prob. of greater F[2]	0.20	NC	0.07
LSD(.10)[3]	NS	NS	0.23
CV, %	1.9	2.3	1.6
Emergence irrigation only, Site No. 2			
None	30.1	55.0	10.8
Vitavax	31.9	55.3	10.9
IMZ	33.6	54.9	11.0
Mean	31.9	55.1	10.9
Prob. of greater F[2]	NC	NC	NC
LSD(.10)[3]	NS	NS	NS
CV, %	17.2	5.4	7.1

[1]Adjusted to 12.5 percent moisture and 60 pounds per bushel.
[2]NC = Not computed because F statistic was less than 1.0
[3]NS = Nonsignificant differences at P = 0.10.

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Early Applications of Ethephon on Furrow-Irrigated Corn

H. D. Sunderman

Summary

Plant height, height to ear, stem diameter, and grain yield of irrigated corn were modified by early-season application of ethephon (Cerone). On average, ethephon application increased grain yield 11 bushels per acre over the untreated control but the range was from -26 to +50. Three of the eight treatment combinations showed yield decreases associated with ethephon. Grain moisture at harvest was generally lower from the early planting date and from plants treated with ethephon. Because of data variability and the questions raised, an expanded experiment will be continued in 1989. In addition to early applications, the effects of late-season, low-rate applications also will be determined.

Introduction

Ethephon is a growth hormone that's marketed in various formulations as Cerone, Prep, and Ethrel. Its use varies with species and formulation but is generally for reducing plant height and lodging. Results with corn have been mixed, possibly because not as much is known about its use on this crop and because timing and rate of application seem to have a narrow margin for error.

Under certain conditions, ethephon has been shown to lower ear height by shortening internode length. Lowering of the ear has been associated with increased lodging resistance. If effective on corn, ethephon may permit the use of certain yield-enhancing agronomic practices and hybrids that are not now used because of associated lodging problems.

Procedures

The site of the replicated experiment was abandoned because it began to show effects from previously applied treatments. So, a nonreplicated experiment was conducted in the bulk area at the end of another experiment, Varying

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Date and Rate of Planting Irrigated Corn under High Soil Fertility Conditions. The production conditions for that experiment apply here (pg. 47).

Ethephon was applied at rates of 0.25 and 0.50 pound of active ingredient per acre on June 22 in 7.8 gallons of solution per acre.

On September 27, the stem diameter 4 inches above the soil surface was measured along the narrow dimension of all the plants within a section of row 8 feet long. At the same time and on the same plants, the height from soil surface to the ear node was measured.

Each two-row plot was trimmed to a uniform length of 46 feet just prior to harvest, and the plots were machine harvested on October 10.

Data for untreated plants were obtained from equivalent plots within the adjacent experiment on date and rate of planting. Treated and untreated plots were separated by distances ranging from 50 to 200 feet.

Results and Discussion

At the time of ethephon application, shoot lengths of the lodging-resistant hybrid were 16 and 4 inches for the first and second planting dates, respectively; lengths were 19 and 4 inches, respectively, for the lodging-susceptible hybrid. All other data are shown in Table 1.

The rate of stem elongation appeared to decrease quickly after the ethephon was applied. A visual difference in plant height between treated and untreated plants was observed in just a few days.

Plants in the early planting were shorter and had generally smaller diameter stems than those in the later planting. Even so, ethephon lowered the ear more on plants in the early planting (average of 5.5 inches) than on those in the later planting (average of 3.9 inches).

The effect of ethephon on height-to-ear was greater for the lodging-resistant hybrid than the lodging susceptible. For the lodging-resistant, the 0.5-pound rate lowered ear height an average of 10.2 inches on the early-planted and 11.0 on the late-planted. In contrast, height to the ear on the lodging-susceptible hybrid was lowered an average of only 4.6 inches (0.25-lb rate) on early-planted and 5.5 inches (0.25-lb rate) on the late-planted.

It appeared that ethephon had a greater effect on ear height and stem diameter of the lodging-resistant hybrid. If so, its use on corn may be further complicated by having to consider the hybrid being grown.

On average, ethephon increased grain yield an average of 11.2 bu/acre. However, the differences ranged from -25.7 to 40.9, with three of the eight treatment combinations showing yield depressions. No lodging was observed in either hybrid, so this was not a factor in the yield differences observed. The number of dropped ears were neither determined nor included in the reported yield but very few were observed during harvest.

Grain moisture at harvest was lower in corn from the early planting date and was generally lower from the plots treated with ethephon.

Because of the variability of response, the same treatments will be applied in a replicated experiment in 1989. Reports out of Nebraska suggest that low application rates of ethephon at tassel emergence cause reduced lodging and faster drying of grain, so this also will be examined.

Table 1. Response of two corn hybrids planted on two dates to application of ethephon, KSU Northwest Research-Extension Center, 1988.

Corn hybrid	Ethephon rate,	Avg. stem diam.	Avg. ht. to ear node	Grain yield	Grain moisture
	lb.ai/ac	----inch----		bu/ac	%
		Planted April 21			
Lodging-resistant	0.00	0.92	44.1	200	22.8
	0.25	0.73	42.1	236	18.4
	0.50	0.80	33.9	185	22.4
Lodging-susceptible	0.00	0.98	43.6	184	20.6
	0.25	0.79	38.2	196	19.5
	0.50	0.77	39.0	223	21.3
		Planted May 2			
Lodging-resistant	0.00	0.89	46.8	202	23.0
	0.25	0.75	45.7	245	23.6
	0.50	0.82	35.8	174	20.7
Lodging-susceptible	0.00	0.96	46.4	183	23.0
	0.25	0.81	40.9	180	22.8
	0.50	0.84	48.4	190	23.8

Seed Density and Seeding Rate for No-Till Winter Wheat

H. D. Sunderman

Summary

Bin-run, foundation-grade Newton seed was separated by a gravity table into four density fractions that ranged from light (57.8 pounds per bushel and 28.1 grams per 1000 kernels) to heavy (61.3 pounds per bushel and 35.2 grams per 1000 kernels) with bin-run testing 57.9 pounds and 26.8 grams. Assuming 90 percent emergence, three density fractions plus bin-run were seeded at a rate to obtain 450, 600, and 750 thousand plants per acre on a no-till fallowed site and 0.8, 1.0, and 1.2 million plants per acre on a conventionally tilled, irrigated site. The fallowed site was abandoned because of poor and uneven stands attributable to drouthy conditions. Exceptionally high temperatures during mid- to late-milk stage caused severe damage to developing grain at the irrigated site. Grain yield, test weight, and 1000-kernel weight were all well below normal levels. Seeding rate had statistically significant effects on grain yield and number of heads at harvest, whereas seed density influenced only 1000-kernel weight. It's likely that the severely adverse conditions experienced during seedling establishment and seed development limited or masked responses this season.

Introduction

Results obtained earlier at Colby demonstrated the advantage of quality seed for obtaining good stands and vigorous early growth--factors frequently associated with higher grain yields. It was projected that, under certain conditions, no-till would create more of a need for high-quality seed than was observed with conventional tillage. No-till will sometimes cause seed and seedling environments that are not conducive to rapid development and, in these situations, it could be expected that quality seed would be required for optimum production. This experiment was begun with assistance from the Kansas Crop Improvement Association to determine if such relationships exist.

Procedures

Bin-run seed of foundation-grade Newton produced at the KSU Northwest Research-Extension Center during the 1986-87 season was first separated into two density fractions on a gravity table. Each of these fractions was then separated into two more fractions. Test weights were determined with standard methods, and four replicates of 100-seed samples were used to determine 1000-kernel weights and germination percentages (Table 1).

Table 1. Characteristics of 1987 Newton seed resulting from gravity table separation.

Fraction number	Experimental designation	Test weight	1000-kernel weight	Germination
		lbs/bu	grams	%
---	Bin-run	57.9	26.8	98
1	"Light"	57.8	28.1	99
2	Discarded	60.1	31.3	97
3	"Medium"	60.2	32.1	98
4	"Heavy"	61.3	35.2	98

From these data, seed packets were prepared by weighing out bin-run, low-, medium-, and high-density seed for seeding with a cone planter. The weights used were calculated to deliver 500, 667, and 833 thousand viable seeds per acre (450, 600, and 750 thousand plants per acre, assuming 90% emergence).

On September 22, plots five 12-inch rows wide by 33 feet long were seeded with a plot drill equipped with staggered, chisel-point openers. Soil at the site was a Keith silt loam that had been uniformly cropped to fallowed no-till wheat for the past eight seasons. Weeds and volunteer wheat had been controlled chemically and 80 pounds of N as ammonium nitrate had been broadcast on the surface prior to seeding. Additionally, a strip immediately adjacent to the plots was prepared with conventional stubble-mulch methods.

Because of adverse seeding conditions, a second site was seeded to provide a backup in the event the first one failed. The second site was also a Keith silt loam, but it had been in continuous wheat for several seasons under sprinkler irrigation. This site had been prepared for irrigated wheat, so seeding rates were increased to 0.89, 1.11, and 1.33 million viable seeds per acre (0.8, 1.0, and 1.2 million plants assuming 90 percent emergence). Residue from this site had been burned after the previous harvest, and 120 pounds of N as ammonium nitrate per acre was applied broadcast and incorporated prior to seeding.

The irrigated site was seeded on September 26 with a simultaneous in-row application of 0-46-0 fertilizer at a rate of 20 pounds P_2O_5 per acre. A light irrigation was applied on October 3 to enhance emergence. Additional irrigations of 1.1 inch were made on April 13 and May 12, 1988. On April 11, 0.75 pint of Brominal ME4, 3/8 ounce of Glean, and 20 pounds of N as urea-ammonium nitrate (UAN) were applied in 20 gallons of solution per acre. On May 10, 1 pint of Cerone-4, 0.25 pint of Tilt 3.6E, and 20 pounds of N as urea-ammonium nitrate were foliarly applied in 20 gallons of solution per acre. Time of this application corresponded to Zodak's code 38 (about 4 inches of flag leaf showing).

Treatments at both sites were arranged in a randomized complete block design with four replications, and the data were analyzed using conventional analysis of variance and multiple range statistical techniques.

In the irrigated plots, 20 row-feet of one row was marked with garden stakes, and the number of heads within this area was counted. On June 28, the above-ground portions of plants within these areas were hand harvested, weighed, and threshed, and resulting grain was weighed. Above-ground dry matter and crop residue were computed from these data, and grain yield, moisture content, test weight, and 1000-kernel weights were determined from the grain samples. The KSU Grain Science Department determined grain protein concentrations on these samples by IR methods.

Results and Discussion

Rainfall during much of the fallow period was well above normal, and stored soil moisture was in fairly good supply. By the middle of July 1987, cumulative precipitation for the year was about 5 inches above the long-time average. However, an extended dry period began then, and very little precipitation was received during the remainder of the year.

As a consequence, moisture was deficient in the seed zone of dryland sites, and seeding operations were accompanied with considerable hope for rain to provide germination and emergence moisture. These rains did not occur. Although some seed was placed in enough soil moisture to germinate and emerge, other seed germinated and died or did not emerge until spring. Because of the adverse soil moisture conditions at seeding, the resulting stands were too uneven for a valid experiment on the fallowed no-till site, and it was abandoned in the spring.

Seedlings began to emerge at the irrigated site on October 2. Good growth was obtained, and no winter-kill was observed. Growth was unremarkable during the spring, although yield prospects appeared excellent. Compared to untreated adjacent areas, Cerone shortened the wheat approximately 6 inches and no lodging was observed. Minor lodging occurred in adjacent areas that were not treated with Cerone.

Rainfall through June 5, 1988 was generally sufficient to produce satisfactory grain yields under dryland conditions. These expectations were not reached because of an extensive period of record-breaking high temperatures and lack of rainfall through harvest. From June 18 through June 26 during the mid- to late-milk stages of development, maximum daily temperatures averaged 103^{o}F, with 3 days reaching 106. As a result, the developing grain was severely damaged and failed to fill to its potential.

Even with a late irrigation on June 12, grain yields (Table 2) from the irrigated site were about 60 percent of normal. Although it appears that the late irrigation helped to reduce the adverse effects on test weight, it was still well below what could have reasonably been expected.

Since the data reported herein represent conditions of only one growing season, there's little that can be concluded with any certainty. It's likely that the season was sufficiently abnormal to have masked responses to a good many agronomic inputs, including seed density and seeding rate. These experiments will be continued during the 1988-89 season.

Table 2. Response of hard red winter wheat to seed density and seeding rate, KSU Northwest Research-Extension Center, 1987-88 season.

Seed density	Seeding rate	Grain Yield	Grain Test weight	Grain Moisture content	Grain Protein concent.	Grain 1000-kernel wt.	No. of Heads	Total dry matter	Crop residue
	million/ac	bu/ac	lbs/bu	------- %	-------	grams	1000/ac	---tons/ac	---
Bin-run	0.8	46.5ab	55.8a	9.9a	13.4a	20.75ab	32.6 c	5.51a	4.16a
	1.0	48.7ab	56.9a	10.1a	13.3a	20.00 b	35.4abc	5.52a	4.10a
	1.2	45.7 b	56.3a	10.2a	13.2a	20.50ab	36.1ab	5.34a	4.01a
Light	0.8	46.4ab	55.5a	9.9a	13.5a	21.25ab	32.7 c	5.47a	4.12a
	1.0	50.9a	56.5a	10.0a	13.4a	21.00ab	33.6 bc	5.69a	4.20a
	1.2	48.7ab	56.1a	9.6a	13.4a	21.00ab	36.0ab	5.63a	4.21a
Medium	0.8	46.3ab	56.1a	10.0a	13.4a	20.75ab	32.6 c	5.32a	3.97a
	1.0	48.3ab	55.8a	10.2a	13.6a	20.00 b	35.3abc	5.55a	4.14a
	1.2	48.0ab	56.6a	9.8a	13.4a	21.00ab	37.6a	5.62a	4.22a
Heavy	0.8	46.1ab	56.8a	10.4a	13.4a	21.50a	33.4 bc	5.45a	4.10a
	1.0	48.2ab	55.5a	9.9a	13.4a	21.50a	36.0ab	5.72a	4.31a
	1.2	48.5ab	56.9a	10.3a	13.3a	21.25ab	38.1a	5.93a	4.51a
				Means for Seed Density					
Bin-Run	---	46.9a	56.4a	10.1a	13.3a	20.42 b	34.7a	5.46a	4.09a
Light	---	48.7a	56.0a	9.9a	13.4a	21.08ab	34.1a	5.60a	4.18a
Medium	---	47.5a	56.2a	10.0a	13.4a	20.58 b	35.1a	5.50a	4.11a
Heavy	---	47.6a	56.4a	10.2a	13.4a	21.42a	35.8a	5.70a	4.31a
				Means for Seeding Rate					
---	0.8	46.3 b	56.0a	10.0a	13.4a	21.06a	32.8 c	5.44a	4.09a
---	1.0	49.0a	56.2a	10.1a	13.4a	20.62a	35.1 b	5.62a	4.19a
---	1.2	47.7ab	56.5a	10.0a	13.3a	20.94a	37.0a	5.63a	4.24a
				Coefficient of Variation, %					
		6.2	1.9	4.7	1.6	3.9	5.5	7.1	8.2

NOTE 1: Grain yields reported at 12.5 percent moisture and 60 pounds per bushel.
NOTE 2: Means within a main effect followed by the same letter are statistically similar according to the Duncan's multiple-range test at P = 0.05.

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Northwest Research-Extension Center, Kansas State University

Transition from Irrigated Corn and Forage Sorghum to Fallowed No-Till Wheat

H. D. Sunderman

Summary

Weather conditions were not favorable during the three seasons in which this experiment has been in progress. Results generally failed to detect any adverse effects of irrigation history on dryland production. Some indication of carry-over nitrogen showed up in grain protein but not grain yield. Differences in residual phosphorus showed no effect in the first season but did affect both grain yield and protein in the last two seasons. Paired-row wheat outyielded equidistantly spaced wheat in 1986 on old corn ground, but the opposite result was obtained on a site formerly planted to forage sorghum. Equidistantly spaced wheat outyielded paired-row wheat substantially in 1988, but yield levels were extremely low.

Introduction

Soils are changed both chemically and physically when irrigation water is applied and the soil is cropped more intensively over a period of years. In recent years, there have been significant movements away from full irrigation of crops having a high water requirement to either those with a lesser water requirement or to a dryland cropping system. Such transitions, particularly to dryland, may involve soil problems not normally encountered in an area with an all-dryland cropping history. This experiment was begun to determine if such problems do exist.

Procedures

Long-term N and P rates studies were initiated on irrigated corn and forage sorghum in 1976 to determine the effects of continuous annual applications on yield and soil nutrient content. The same treatment was applied to the same plot each year except 1) nitrogen rates on corn were revised downward in 1981 from 75, 150, 225, and 300 pounds of N per acre to 65, 130, 190, and 250 pounds and 2) phosphorus applications were discontinued in 1982. Ammonium nitrate (33.5-0-0) and concentrated superphosphate (0-46-0) were applied broadcast in the spring and incorporated prior to planting. Nitrogen and phosphorus fertilizer treatments had been applied in a complete factorial, randomized complete block design with four replications for both corn and forage sorghum. These studies were terminated following harvest in 1982, and the sites were cropped to a no-till fallow-wheat rotation. Because of a dry seed zone, the first wheat seeding was delayed to the spring of 1984 (see Report of Progress 476).

Following the 1984 harvest, the plots were continued under no-till conditions. In both 1985 and 1987, the plots were split and half was seeded in a paired-row configuration (6- and 18-inch spacing) and half to equidistant 12-inch row spacing. Each row configuration contained the same number of row feet per acre and the same number of seeds per foot of row.

The paired-row configuration was achieved with Hanby units (modifications now marketed by Hiniker) mounted on alternate chisel plow shanks, with seed delivered to the furrow by air. The equidistant spacing was achieved with Ace openers mounted on each chisel plow shank. Nitrogen was applied at a constant rate of 60 pounds per acre using UAN 32-0-0. In the paired-row, UAN placement was mid-way between and 3 inches below the paired rows, whereas it was over the row on equidistant spacings.

Results and Discussion

Climatic Influence

In 1986, a drouthy spring, late freeze, and hail reduced yields substantially. Likewise, the last 5.5 months of 1987 were extremely dry, and seeding was done under very poor moisture conditions. Seedling emergence was slow and uneven, and poor stands developed. As a result of adverse climatic conditions in all three years, grain yields were abnormally low.

Residual Nitrogen

Although preliminary soil samples failed to show differences in residual nitrogen (see Report of Progress 454), wheat grain protein content generally increased with increasing N rates applied when the sites were in corn

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(Table 1) and forage sorghum (Table 2). Nitrogen applied to irrigated corn and forage sorghum influenced wheat grain yield only in 1988, when the yields were extraordinarily low.

A good range of phosphorus soil test levels had been created, while the sites were being cropped to corn and forage sorghum. Even so, no responses to P were observed during the first season into wheat. Good responses to residual P were obtained in 1986, and the response was greater following forage sorghum than following corn, suggesting that forage sorghum removed more of the P applied than did corn.

Row Configuration

The paired-row seeding provided a wide middle for walking the plots, a feature that may be particularly useful when roguing certified seed production fields. Few weed problems were observed but, when they did occur, they were in the wide, unshaded middles between pairs of rows.

In 1986, the wheat in paired-row spacing produced statistically greater grain yields than that in the equidistant spacing when seeded on the site that was formerly in irrigated corn (Table 1). The opposite was found when wheat was seeded on the site formerly in irrigated grain sorghum (Table 2). Although yields were substantially higher from wheat in equidistant spacings compared to paired-row in 1988, the comparison has little value because of the low yield levels obtained.

Because of the influence of adverse climatic conditions to date on wheat stands and grain yield, the experiment will be continued during the 1988-89 season.

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Table 1. Yield and protein content of no-till winter wheat one, two, and three fallow sequences after conventionally tilled, irrigated corn, KSU Northwest Research-Extension Center, 1984[1], 1986, and 1988.

$N-P_2O_5$ rates on corn		Grain yield					Grain protein				
		Paired-row		Equidistant			Paired-row		Equidistant		
		1986	1988	1984	1986	1988	1986	1988	1984	1986	1988
lbs./acre		------- bu./acre -------					----------- % -----------				
0	0	46	10	33	47	15	13.0	13.7	11.9	12.7	13.1
	45	46	11	33	49	16	12.7	13.0	11.7	12.2	13.0
	90	45	11	34	52	16	12.3	13.2	11.5	12.6	12.5
	Mean	45	11	33	49	16	12.7	13.3	11.7	12.5	12.9
65	0	41	8	32	41	11	12.9	13.7	12.3	12.9	13.5
	45	42	12	34	48	13	12.4	13.3	11.7	12.6	12.9
	90	46	8	32	49	15	13.0	13.5	12.4	12.6	13.0
	Mean	43	9	33	46	13	12.8	13.5	12.0	12.7	13.2
130	0	42	8	32	37	10	13.3	13.8	12.5	13.0	14.0
	45	40	4	32	45	10	12.9	14.7	12.4	12.9	13.3
	90	46	6	33	51	11	12.8	14.1	12.3	12.9	13.2
	Mean	43	6	32	44	10	13.0	14.2	12.4	12.9	13.5
190	0	43	5	34	41	9	13.0	14.3	12.5	13.0	13.9
	45	43	4	31	44	13	13.2	14.4	12.5	13.2	13.2
	90	46	7	33	47	12	13.1	13.5	12.4	12.8	13.2
	Mean	44	5	33	44	11	13.1	14.1	12.5	13.0	13.4
250	0	41	3	32	43	12	13.3	14.1	12.8	13.2	13.5
	45	46	4	35	46	12	13.0	14.2	12.5	13.1	13.4
	90	43	5	33	48	13	13.0	14.6	12.8	13.4	13.4
	Mean	43	4	33	46	12	13.1	14.3	12.7	13.2	13.4
Means for P_2O_5 Rates											
	0	43	7	33	42	11	13.1	13.9	12.4	13.0	13.6
	45	44	8	33	46	13	12.8	13.9	12.2	12.8	13.2
	90	45	7	33	49	13	12.8	13.8	12.2	12.8	13.1
Means for Row Configuration											
		44	7	--	46	12	12.9	13.9	--	12.9	13.3
Source of Variation		LSD (0.05)									
Row Config.		0.6	*	--			*	*	--		
N Rate		2.2	1.4	NS			0.2	0.2	NS		
RC x NR		NS	NS	--			NS	NS	--		
P Rate		1.7	NS	NS			0.1	NS	NS		
RC x PR		2.4	NS	--			NS	0.1	--		
NR x PR		NS	NS	NS			NS	NS	NS		
R x NR x PR		NS	NS	--			NS	0.3	--		

[1] Spring-planted winter wheat this year only.

* Significant at P = 0.05 level.

Table 2. Yield and protein content of no-till winter wheat one, two, and three fallow sequences after conventionally tilled, irrigated forage sorghum, KSU Northwest Research-Extension Center, 1984[1], 1986, and 1988.

$N-P_2O_5$ rates on corn		Grain yield					Grain protein				
		Paired-row		Equidistant			Paired-row		Equidistant		
		1986	1988	1984	1986	1988	1986	1988	1984	1986	1988
lbs./acre		bu./acre					%				
0	0	35	5	31	31	13	12.0	13.9	10.5	12.0	13.2
	45	38	10	31	37	18	11.6	12.8	10.9	11.8	12.5
	90	37	9	27	35	17	12.1	13.2	10.7	11.8	12.4
	Mean	37	8	29	35	16	11.9	13.3	10.7	11.9	12.7
65	0	37	8	28	28	13	12.2	13.6	11.0	12.6	13.4
	45	41	9	29	33	14	11.8	13.4	11.5	11.9	13.1
	90	40	9	30	35	18	11.5	13.0	11.3	12.0	12.2
	Mean	39	9	29	32	15	11.8	13.3	11.3	12.2	12.9
130	0	36	7	28	30	12	12.0	13.4	11.7	12.6	13.3
	45	38	7	28	34	14	12.0	13.5	11.7	12.1	12.8
	90	40	9	27	35	17	11.9	13.2	11.6	11.9	12.8
	Mean	38	8	27	33	14	12.0	13.4	11.6	12.2	13.0
190	0	28	8	29	24	17	12.7	13.8	11.4	12.7	12.9
	45	39	5	29	35	9	12.3	14.0	11.9	12.3	13.4
	90	42	7	30	36	14	12.1	13.7	11.7	12.2	12.8
	Mean	37	6	30	32	13	12.4	13.8	11.7	12.4	13.0
Means for P_2O_5 rates											
	0	34	6	29	28	14	12.2	13.6	11.1	12.5	13.2
	45	39	8	29	35	14	12.0	13.4	11.5	12.0	13.0
	90	40	8	28	35	17	11.9	13.3	11.3	12.0	12.5
Means for row configuration											
		38	8	--	33	15	12.0	13.5	--	12.2	12.9

Source of Variation	LSD (0.05)					
Row Config.	*	*	--	*	*	--
N Rate	NS	0.8	NS	0.2	0.2	0.3
RC x NR	NS	NS	--	NS	NS	--
P Rate	1.9	1.5	NS	0.2	0.2	NS
RC x PR	NS	NS	--	NS	NS	--
NR x PR	3.7	3.1	NS	NS	0.4	NS
R x NR x PR	NS	NS	--	NS	NS	--

[1] Spring-planted winter wheat this year only.

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Cultural Practices for Continuous Grain Sorghum

F. R. Lamm

Summary

Eight years of results with continuous grain sorghum show the feasibility of using this annual cropping system when soil water is sufficient. The average grain sorghum yield for the period 1982-1988 was 62.3 bu/a. Continuous dryland grain sorghum is a more risky cropping alternative, since soil water reserves may not be as high at planting as those of fallowed land. These reserves are generally not sufficient to produce a crop alone, and timely summer precipitation is needed for both fallow and continuous systems.

Introduction

Research has shown that much of the accumulation of soil water during the fallow period occurs in the first winter and the next spring. In wheat-fallow systems, the soil is often near field capacity by late May or early June, and precipitation received during the rest of the fallow period is often lost to evaporation, deep percolation, and run-off. Five years (1981-1985) of results have indicated that dryland, continuous, narrow-row, grain sorghum is a feasible alternative to fallow grain sorghum, in northwestern Kansas. However, it is riskier than fallow grain sorghum, and yields may be affected by lower water reserves in dry years. This study was initiated in the fall of 1985 to further examine and develop cultural practices for continuous grain sorghum.

Procedures

The objective of the new study is to optimize tillage and fertilization practices for high population, continuous, dryland grain sorghum. The six tillage-planting treatments selected for examination were as follows:

1. No tillage-15 inch grain sorghum rows
2. No tillage-30 inch grain sorghum rows
3. Spring disk-15 inch grain sorghum rows
4. Spring disk-30 inch grain sorghum rows
5. Fall disk and furrow dams-30 inch grain sorghum rows
6. Spring disk and furrow dams-30 inch grain sorghum rows

The fall furrow-damming treatments were applied on October 8, 1987. The spring disk treatments were applied on April 15, 1988.

All plots were sprayed on April 15, 1987 with Dual, 1.75 pt/a; Miloguard, 0.75 qt/a; and Landmaster, 2.5 qt/a. The study was planted to Funks G-550 grain sorghum on May 27, 1987 at a population of 63,000 plants/acre. Three fertilizer treatments, 30, 60, and 90 lbs. N/acre, were superimposed on the study at planting with liquid fertilizer applied to the side of the seed. Soil water was measured after planting on June 13, 1988 and again after harvest on October 11, 1988. A sample from each plot was harvested by hand on September 29, 1988 for yield determination.

Similar procedures were used in 1986 and 1987, though actual dates of treatment varied.

Results and Discussion

There were no significant differences in available soil water between tillage-planting treatments at planting in 1988 (data not shown). Available soil water at planting ranged from 5.0 to 7.2 inches in the 5-foot soil profile. These levels of soil water are somewhat lower than levels seen in earlier years of the study.

Grain yields varied greatly in 1988 (Table 1) for continuous grain sorghum, ranging from 2.6 to 86.7 bu/acre. There were significant differences (P=.05) in yields attributable to both tillage-planting treatments but not fertilizer rate in 1988. The highest yield was obtained from the 15-inch, no-tillage treatment. Likewise, water use efficiencies (WUE) were highest for this treatment. Furrow damming resulted in very low yields. In fact, spring furrow damming resulted in essentially a crop failure. The failure was probably caused by early, luxurious vegetative growth, which used up the available water too soon. An aeration problem caused by the furrow damming operation also may have reduced yields.

Table 1. Yield and water use data for continuous dryland grain sorghum as affected by tillage, row spacing, and nitrogen rate, KSU Northwest Research Extension Center, 1986-88.

Tillage trt.	N rate	Yield 1986	Yield 1987	Yield 1988	Yield Mean	Water use 1986	Water use 1987	Water use 1988	Water use Mean	WUE[1] 1986	WUE[1] 1987	WUE[1] 1988	WUE[1] Mean
	lbs/acre	bu/a				inches				lbs/a-in			
No-tillage (15-in.)	30	46.3	114.7	64.8	75.3	12.0	15.1	13.0	13.4	217	428	263	303
	60	61.7	136.8	62.4	87.0	14.1	15.4	13.5	14.3	247	505	256	336
	90	59.9	138.0	86.7	94.9	12.0	15.7	12.9	13.5	296	491	378	388
	Mean	56.0	129.9	71.3	85.7	12.7	15.4	13.1	13.7	253	474	299	342
No-tillage (30-in.)	30	58.9	79.1	56.2	64.7	11.3	15.6	13.1	13.3	289	284	240	271
	60	64.1	101.7	45.1	70.3	12.0	15.9	13.3	13.7	326	356	189	290
	90	65.7	94.1	51.2	70.3	12.0	16.5	13.3	13.9	322	320	216	286
	Mean	62.9	91.7	50.8	68.5	11.8	16.0	13.2	13.7	312	320	215	282
Disk-spring (15-in.)	30	49.7	95.1	30.6	58.5	13.3	16.1	12.2	13.9	211	332	142	228
	60	63.0	110.4	52.1	75.2	13.7	15.9	12.3	14.0	258	392	237	296
	90	49.3	88.0	39.8	59.0	12.7	16.2	12.2	13.7	223	309	184	239
	Mean	54.0	97.8	40.8	64.2	13.2	16.0	12.2	13.8	231	344	188	254
Disk-spring (30-in.)	30	53.3	73.1	46.3	57.6	11.4	15.2	13.0	13.2	259	263	196	239
	60	55.0	70.7	45.1	56.9	12.2	15.2	12.7	13.4	261	258	195	238
	90	45.6	68.5	41.2	51.8	12.7	15.8	13.2	13.9	212	238	173	208
	Mean	51.3	70.8	44.2	55.4	12.1	15.4	13.0	13.5	244	253	188	228
Furrow Dams (fall)	30	54.1	62.3	27.1	47.8	12.3	14.1	11.8	12.7	245	246	129	207
	60	54.9	69.7	32.3	52.3	14.2	14.1	11.9	13.4	215	271	150	212
	90	54.5	56.6	26.0	45.7	12.2	14.5	11.9	12.9	256	212	118	195
	Mean	54.5	62.9	28.5	48.6	12.9	14.2	11.8	13.0	239	243	133	205
Furrow Dams (spring)	30	48.5	60.5	7.9	39.0	12.3	15.3	11.8	13.1	246	224	36	169
	60	53.6	68.4	2.6	41.5	12.9	15.6	12.1	13.5	235	244	12	164
	90	52.5	51.7	5.1	36.4	12.1	15.7	11.6	13.1	242	186	25	151
	Mean	51.5	60.2	5.2	39.0	12.4	15.5	11.9	13.3	241	218	24	161
Mean		55.0	85.5	40.1	60.2	12.5	15.4	12.5	13.5	253	309	174	245
LSD.05 (Tillage)		NS	33.1	9.6	--	NS	NS	NS	--	NS	103	40	--
Mean (Nitrogen)	30	51.8	80.8	38.8	57.1	12.1	15.2	12.5	13.3	245	296	168	236
	60	58.7	93.0	39.9	63.9	13.2	15.4	12.6	13.7	257	338	173	256
	90	54.6	82.8	41.7	59.7	12.3	15.7	12.5	13.5	259	293	183	245
LSD.05 (Nitrogen)		NS	9.9	NS	--	NS	0.3	NS	--	NS	38	NS	--

[1] Water use efficiency (WUE) is defined as yield in lb/a divided by total water use in inches.

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Highest yield and WUE with respect to fertilizer treatment was obtained by the 90 lbs. N/acre treatment. In 1986 and 1987, the 60 lbs. N/acre rate gave the highest yield and water use efficiency.

A summary of 8 years' results with continuous grain sorghum is given in Table 2. The 1981-1985 studies were different in scope from the 1986-88 studies, so only annual means are shown. However, the results can give some indication of how continuous grain sorghum fares in relation to other dryland conservation alternatives.

Continuous dryland grain sorghum is a riskier cropping alternative, since soil water reserves may not be as high at planting as those of fallowed land. When available soil water is below 50% at planting, continuous cropping is probably not warranted. However, these results demonstrate the feasibility of using annual cropping when soil water is sufficient. However, soil water reserves at planting are generally not sufficient to produce a crop alone, and timely summer precipitation is needed for both fallow and continuous systems.

Table 2. Summary of yield and water use data for continuous dryland grain sorghum, KSU Northwest Research-Extension Center, 1981-1988.

Year	Grain yield	Water use	WUE[1]
	bu/a	inches	lb/a-in
1981	94.7	9.0	595
1982	77.6	20.4	214
1983	21.8	11.0	110
1984	52.8	14.7	184
1985	70.9	16.2	246
1986	55.0	12.5	253
1987	85.5	15.4	309
1988	40.1	12.5	174
Mean	62.3	14.0	261

[1] Water use efficiency (WUE) is defined as yield in lb/a divided by total water use in inches.

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Tillage and Fertilization Effects on Corn Yield and Water Use for the Wheat-Corn-Fallow System

F. R. Lamm

Summary

Results from studies during the period 1982-1988 show that corn yields in the wheat-corn-fallow system generally are better with no tillage than with disk tillage systems. Good residue management often resulted in more soil water stored for corn use. Fall disking in 1987 resulted in significantly lower corn yields in the following year. Yields were 68, 82, and 84 bu/a for the disk-in-fall, no-tillage and disk-in-spring treatments, respectively. In 1988, no significant differences resulted from fertilizer rates ranging from 40 to 120 lbs N/a.

Introduction

There has been a renewed interest in dryland corn production in northwestern Kansas, particularly in the northern tier of counties. Problems such as early freezes, cool summers, and greenbug infestations have prompted some farmers to examine dryland corn as an alternative to the more traditional dryland summer crop of grain sorghum. Improvements in water conservation technology over the years have taken some of the risk out of producing dryland .mt 7corn. In 1982, a study was initiated at the Northwest Research-Extension Center to evaluate the potential for corn grown in a wheat-corn-fallow (WCF) system and to determine how tillage influences yield and water use. In 1986, the study was modified to examine tillage and fertilizer effects on yields and water use.

Procedures

After the 1987 wheat harvest, residual herbicides (Bladex 4L, 1.5 qt/a and Ally 0.1 oz/a) were applied on August 3 to control weeds until spring. In addition, 54 oz of Landmaster/a was added to kill existing weeds. On April 29, 1988, 1.5 pt of Dual 8E and 1.5 qt of Atrazine per acre were applied.

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Three tillage treatments were investigated: disk-in-fall (8-3-87), disk-in-spring (4-29-88), and no tillage. The fertilizer treatments included nitrogen (ammonium nitrate) broadcast applied soon after planting at rates of 40, 80, and 120 lbs./acre.

Pioneer brand 3475 corn was initially planted on April 29, 1988 at the rate of 12,000 plants/acre. Poor stands because of cool, wet weather and heavy soil crusting resulted in the need to replant on May 16, 1988. A sample from each plot was harvested by hand on September 13, 1988.

Neutron probe access tubes for soil moisture measurements were installed in each plot with the medium nitrogen rate. Measurements were made periodically throughout the season in 1-foot increments to a depth of 8 feet.

Similar procedures were followed during the 1986 and 1987 crop year, though the actual dates varied.

Results and Discussion

Seasonal precipitation in 1987 was lower than normal, with the May through August amount being 10.81 inches compared to a normal 11.23 inches. June was very dry, and evapotranspiration was high. However, timely rains in July and August were extremely beneficial during the critical growth stages for the corn. Weed control was good in 1988, and the corn was able to make good use of available soil water and precipitation.

There were no significant differences attributable to fertilizer rate during the period from 1986-1988. Average yields for the three nitrogen rates varied less than 2 bu/a (data not shown), with the highest average yield obtained with 40 lb N/acre.

There were significant differences (P=.05) in yields in all years as a result of tillage (Table 1). In most years, higher yields were obtained under the no-tillage treatment, followed by the disk-in-spring and the disk-in-fall treatments. In most years, there were significant differences in the average number of ears/plant and the average kernel weight, with the no-tillage plots outperforming the disk-tillage plots. The higher yields for no-tillage plots reflect improved conservation and use of available water.

Table 1. Corn yield component and water use data as affected by tillage in a wheat-corn-fallow study, 1986-88, KSU Northwest Research Extension Center.

Tillage treatment	Year	Yield components			Yield	Water use	WUE[1]
		ears/ plant	seeds /ear	gm/100 seeds	bu/A	inches	lbs/ A-in
No-tillage	1986	1.00	603	25.97	80.7	13.97	324
	1987	1.29	523	28.34	88.9	13.30	374
	1988	1.50	343	31.10	82.4	12.12	382
	Mean	1.26	490	28.47	84.0	13.13	360
Disk-in-fall	1986	0.93	493	21.91	52.6	12.06	244
	1987	1.19	506	21.52	64.6	12.03	301
	1988	1.45	340	27.82	68.0	11.59	328
	Mean	1.19	446	23.75	61.7	11.89	291
Disk-in-spring	1986	0.99	574	23.92	69.4	13.79	282
	1987	1.06	549	25.29	75.3	13.12	321
	1988	1.61	358	30.31	83.8	12.37	380
	Mean	1.22	494	26.51	76.2	13.09	328
MEAN	1986	0.97	557	23.93	67.6	13.27	283
LSD (.05)		0.04	86	1.57	9.2	0.76	38
MEAN	1987	1.18	526	25.04	76.3	12.81	332
LSD (.05)		0.14	NS	1.73	9.7	0.73	44
MEAN	1988	1.51	347	29.74	78.1	12.02	363
LSD (.05)		NS	NS	0.70	4.0	NS	19

[1] Water Use Efficiency (WUE) is defined as yield in lbs/acre divided by water use in inches.

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In related studies, no-tillage treatments have had better or nearly equal yields to the tilled treatments, with the exception of 1985, a very wet summer (Table 2 and Figure 1).

Dryland corn production is a possible alternative to dryland grain sorghum. However, there are some points worth noting. In good years, corn grown in a wheat-corn-fallow system will probably out-yield grain sorghum grown in a wheat-sorghum-fallow system. In poor years, the opposite is true. Grain sorghum generally will have less year to year variability, which is important to those producers who want to minimize risk.

Table 2. Summary of corn yield and water use data from wheat-corn-fallow studies, 1982-1988, KSU Northwest Research Extension Center.

Tillage system	Year	Grain yield	Water use	WUE[1]
		bu/A	inches	lbs/A-in
No-Tillage	1982	85.0	14.3	333
	1983	37.1	9.7	214
	1984	44.7	9.8	247
	1985	86.4	10.6	262
	1986	80.7	14.0	323
	1987	88.9	13.3	374
	1988	82.4	12.1	360
	Mean	72.2	12.0	302
Disk in Fall	1984	47.6	9.3	254
	1985	103.7	11.5	305
	1986	52.6	12.1	244
	1987	64.6	12.0	301
	1988	68.0	11.6	328
	Mean	67.3	11.3	286
Disk in Spring	1982	75.2	15.4	274
	1983	34.6	9.1	213
	1984	45.9	9.5	251
	1985	91.7	10.4	276
	1986	69.4	13.8	282
	1987	75.3	13.1	321
	1988	83.8	12.4	380
	Mean	68.0	12.0	285

[1] Water Use Efficiency (WUE) is defined as yield in lbs/acre divided by water use in inches.

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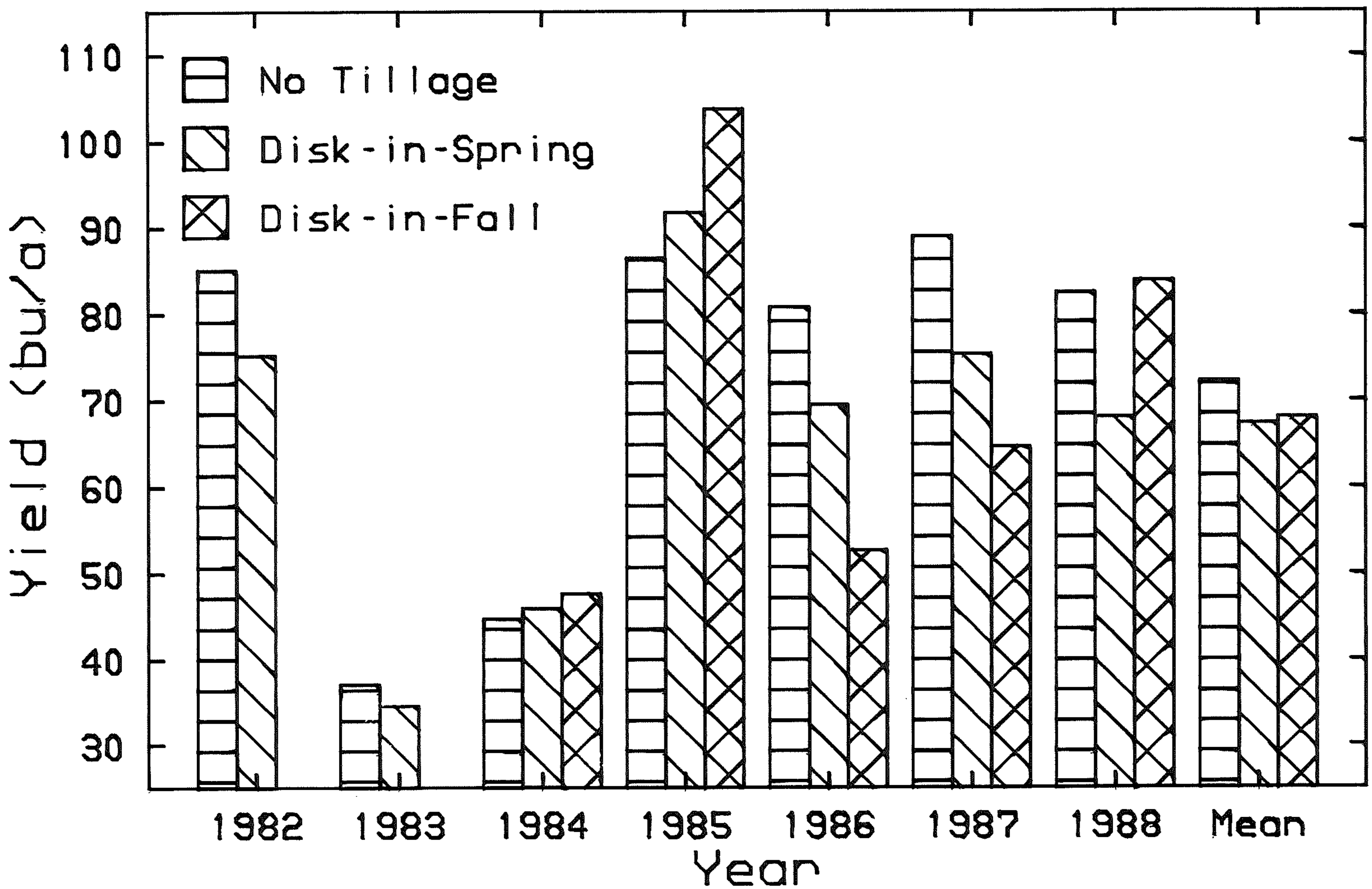

Figure 1. Dryland corn yields as affected by tillage in wheat-corn-fallow studies, 1982-1988, KSU Northwest Research-Extension Center.

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