Southwest Research-Extension Center

FIELD DAY

1998

REPORT OF PROGRESS
814

KANSAS STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
AND COOPERATIVE EXTENSION SERVICE

K-STATE
Kansas State University

Pat Coyne - Center Head. B.S. degree, Kansas State University, 1966; Ph.D. degree, Utah State University, 1969. He joined the KSU faculty in 1985 as Head of the Agricultural Research Center--Hays. He was appointed head of the three western Kansas ag research centers at Hays, Garden City, and Colby in 1994. Research interests have focused on plant physiological ecology and plant response to environmental stress.

Paul Hartman - Associate Head and Area Extension Director, Paul received his B.S. and M.S. in Animal Sciences and Industry from Kansas State University. Prior to that, he served as County Extension Agricultural Agent in Stanton and Pratt counties.

Mahbub Alam - Extension Specialist, Irrigation and Water Management. Mahbub received his M.S. from American University of Beirut, Lebanon, and Ph.D. from Colorado State University. He joined the staff in 1996. Mahbub previously worked for Colorado State University as an Extension Irrigation Specialist. His extension responsibilities are in the area of irrigation and water management.

Larry Buschman - Entomologist. Larry received his M.S. at Emporia State University and his Ph.D. at the University of Florida. He joined the staff in 1981. His research includes studies of the biology, ecology, and management of insect pests, with emphasis on pests of corn - including spider mites.

Randall Currie - Weed Scientist. Randall began his agriculture studies at Kansas State University, where he received his B.S. degree. He then went on to receive his M.S. from Oklahoma State University and his Ph.D. from Texas A&M University. His research emphasizes weed control in corn.

Jeff Elliott - Research Farm Manager. Jeff received his B.S. from the University of Nebraska. In 1984, Jeff began work as an Animal Caretaker III and was promoted to Research Farm Manager in 1989.

Dave Frickel - Research Associate - Tribune. Dave received his B.S. from the University of Nebraska-Lincoln in 1987. He began his work here as an Agricultural Technician. In 1991, he moved to his current position.

Kelly Kreikemeier - Ruminant Nutritionist. Kelly received his B.S. and M.S. from University of Nebraska-Lincoln, and his Ph.D. from Kansas State University. He began his research here in 1994 with emphasis on nutrition and management of feedlot cattle.

CONTENTS

1998 RESEARCH-EXTENSION CENTER STAFF

Patrick Coyne	Head
Paul Hartman	Area Extension Director
Mahbub Ul Alam	Extension Specialist - Irrigation
Larry Buschman	Corn Entomologist
Randall Currie	Weed Scientist
Les DePew	Professor Emeritus
Jeff Elliott	Research Farm Manager
Andy Erhart	Professor Emeritus
David Frickel	Research Associate, Tribune
Gerald Greene	Professor Emeritus
George Herron	Professor Emeritus
Kelly Kreikemeier	Animal Scientist
Ray Mann	Professor Emeritus
Charles Norwood	Agronomist-Dryland Soil Management
Alan Schlegel	Agronomist-in-Charge, Tribune
Phil Sloderbeck	Extension Specialist, Entomology
Curtis Thompson	Extension Specialist, Crops and Soils
Todd Trooien	Agriculture Engineer-Water Management
Merle Witt	Agronomist-Crop Production
Carol Young	Extension Home Economist

1998 SUPPORT PERSONNEL

Jovita Baier, Office Specialist
Marvin Cronin, Jr., Agricultural Technician
John Fleming, Agricultural Technician
Manuel Garcia, Gen. Maintenance & Repair Tech. II
Marsha Harris, Agricultural Technician
Michele Hedberg, Agricultural Technician - Tribune
Roberta Huddleston, Keyboard Operator III
William Irsik, Mechanic II
Sabrina Keidel, Keyboard Operator III
Joanna Meier, Accountant I
Henry Melgosa, Plant Science Technician II
Gary Miller, Plant Science Technician II
Dale Nolan, Plant Science Technician II - Tribune
David Romero, Jr., Mechanic I
Lori Saueressig, Keyboard Operator III
Sharon Schiffelbein, Secretary III
Ramon Servantez, Plant Science Technician II
Monty Spangler, Agricultural Technician
Dennis Tomsicek, Agricultural Technician
Marilyn Vass, Animal Science Technician II
Carl Warner, Gen. Maintenance & Repair Tech. I
John Wooden, Plant Science Technician II
Jennifer Wright, Agricultural Technician

Southwest Research-Extension Center
4500 East Mary, Bldg. 924
Garden City, KS 67846
316-276-8286
Fax No. 316-276-6028

Note: Trade names are used to identify products. No endorsement is intended, nor is any criticism implied of similar products not mentioned.

Contribution 98-494-S from the Kansas Agricultural Experiment Station.

WEATHER INFORMATION FOR GARDEN CITY

by

Jeff Elliott

Total precipitation for 1997 was 24.82 inches, well above the 30-year average of 17.91 inches. This was the wettest year since 1972 and the ninth consecutive year with above-average precipitation. This is the longest "wet" period since records began at Garden City in 1908. For the second year in a row, August was the wettest month. The 6.93 inches of precipitation made this the wettest August ever recorded at Southwest Research-Extension Center. The months of May, June, July, and August totaled over 18 inches of rainfall, which approximates the average precipitation for an entire year. Snowfall in 1997 was also above average, totaling 28.25 inches compared to 17.7 inches in a normal year. The largest single snowfall for the year was recorded on October 26, piling up 11 inches, which contained 0.9 inches of moisture. Measurable precipitation was recorded on 76 days during the year compared to a 67-day average.

July was the warmest month, with an average temperature of 77.6 ° and an average high temperature of 91.5°. January was the coldest, with a mean temperature of 28.5° and a mean low temperature of 13.4°. Monthly mean temperatures for 1997 did not deviate appreciably from the 30-year averages.

Daily minimum temperatures below zero were recorded on only four occasions, with the coldest being -6° on January 13. Temperatures above 100° occurred only three times, with the highest being 103° recorded on July 2 and also on September 19.

Five temperature records were broken or tied in 1997. Record high temperatures occurred on September 19 (103°) and on October 3 (95°). Low temperature records were set on April 12 (9°), October 27 (12°), and on November 26 (-2°).

The last spring freeze was on May 3, which was 7 days later than normal. The first fall freeze occurred on October 26. This was 14 days later than normal, resulting in a frost-free period of 176 days. The normal frost-free period is 169 days. The 1997 frost-free period was the longest since 1988.

Table 1. Weather data. Southwest Research-Extension Center, Garden City, KS.

	Precipitation inches		Temperature(°F)						Wind MPH		Evaporation inches	
			97 Average		Mean		97 Extreme					
Month	1997	Avg.	Max.	Min.	1997	Avg.	Max.	Min.	1997	Avg.	1997	Avg.
January	0.28	0.33	43.6	13.4	28.5	27.9	73	-6	5.4	4.8		
February	0.75	0.45	46.0	18.8	32.4	32.8	75	5	6.3	5.5		
March	0.00	1.15	63.8	25.6	44.7	41.3	86	10	7.5	7.0		
April	1.30	1.56	60.8	31.8	46.3	52.7	85	9	7.0	7.0	6.74	8.75
May	4.49	3.11	75.1	47.2	61.1	62.2	94	32	5.9	6.4	10.20	10.67
June	5.55	2.87	83.1	59.2	71.2	72.4	102	50	5.0	6.0	10.77	12.89
July	1.10	2.60	91.5	63.6	77.6	77.9	103	53	5.3	5.2	13.88	14.19
August	6.93	2.16	86.8	62.2	74.5	75.4	97	52	4.0	4.5	10.09	11.66
September	0.80	1.59	83.1	55.4	69.3	66.6	103	43	4.6	4.9	8.73	8.84
October	2.04	0.98	69.9	40.9	55.4	55.0	95	12	6.0	4.8		
November	0.29	0.76	52.5	25.7	39.1	41.1	72	10	5.0	4.8		
December	1.29	0.35	39.6	21.4	30.5	30.7	60	-2	5.2	4.5		
Annual	**24.82**	**17.91**	**66.3**	**38.8**	**52.6**	**53.0**			**5.6**	**5.5**	**60.41**	**67.0**

Average latest freeze in spring	April 26	1997:	May 3
Average earliest freeze in fall	Oct. 12	1997	Oct. 26
Average frost-free period	169days	1997:	176 days

All averages are for the period 1961-90.

WEATHER INFORMATION FOR TRIBUNE

by

David Frickel and Dale Nolan

Precipitation for 1997 totaled 24.72 inches, which was 8.76 inches above normal. Precipitation was above-normal in 8 months. The wettest months were June, July, August, and October, with 3.37 inches, 5.32 inches, 4.41 inches, and 4.00 inches, respectively. March was the driest month with no measurable precipitation. The largest single amount of precipitation was 2.86 inches on August 6, and 3.91 inches were recorded for the 3-day period of July 28 through July 30. The greatest single amount of snowfall in a 24-hour period was 19.0 inches reported on October 26, which exceeded the previous record of 18 inches on March 29, 1987. The greatest monthly amount of snowfall, 22.0 inches, also was received in October. Snowfall for the year totaled 56.5 inches, snow cover occurred for a total of 54 days. The longest consecutive period of snow cover, 16 days, was from December 3 to December 18.

The air temperature was above normal for only 4 months. July was the warmest month with a mean temperature of 76.4° and an average high temperature of 93.0°. The coldest month was January with a mean temperature of 27.9°, an average high of 43.6°, and an average low of 12.2°. No record high temperatures were set in 1997. Record low temperatures were set on April 11, 12, 13 and 14; May 3 and 9; July 6; and October 26 and 27.

Deviation from the normal was greatest in April, when the mean temperature was 6.0° below normal. Nine days had temperatures of 100° or above, compared to the 30-year average of 10 days, and 57 days had temperatures of 90° and above compared to the 30-year average of 63 days. The lowest temperature for the year was -9° on January 13, and the highest was 102° on June 21 and July 2. The last reading of 32° or less in the spring was on May 13, which is 10 days later than the normal date, and the first reading of 32° or less in the fall was on October 9, which is 6 days later than the normal date. The frost-free period was 149 days, which is 4 days less than the normal of 153 days.

Open pan evaporation from April through September totaled 59.49 inches, which was 12.18 inches below normal. Wind speed for the same period averaged 4.4 mph, which is 1.3 mph less than normal.

Table 1. Weather data. Southwest Research-Extension Center, Tribune, KS.

	Precipitation inches		Temperature (°F) 1997 Average		Normal		1997 Extreme		Wind MPH		Evaporation inches	
Month	1997	Normal	Max.	Min.	Max	Min.	Max.	Min.	1997	Avg.	1997	Avg.
January	0.12	0.36	43.6	12.2	43.3	14.2	75	-9				
February	0.97	0.40	45.9	17.0	48.7	18.7	75	-1				
March	0.00	0.99	62.1	24.8	56.6	25.4	84	10				
April	1.41	1.13	59.1	28.1	67.5	35.1	84	8	5.4	6.6	5.77[1]	8.82
May	1.56	2.69	74.0	41.9	76.0	45.3	92	25	4.7	6.0	9.80	10.95
June	3.37	2.71	83.7	55.7	86.9	55.3	102	49	4.3	5.7	10.68	13.71
July	5.32	2.60	93.0	59.8	92.7	61.3	102	47	4.9	5.5	16.26	15.64
August	4.41	1.98	86.2	58.8	89.9	59.2	96	51	3.3	5.2	9.17	13.01
September	1.84	1.54	82.6	51.7	81.3	49.9	99	42	4.0	5.4	7.81	9.55
October	4.00	0.74	67.1	36.4	70.4	37.3	93	12				
November	0.06	0.49	50.6	23.1	54.7	25.3	70	9				
December	1.66	0.33	37.6	18.6	44.9	16.6	55	5				
Annual	**24.72**	**15.96**	**65.6**	**35.8**	**67.7**	**37.0**	**102**	**-9**	**4.4**	**5.7**	**59.49**	**71.67**

Average latest freeze in spring[2]	May 3	1997:	May 13
Average earliest freeze in fall	October 3	1997:	October 9
Average frost-free period	153 days	1997:	149 days

[1]Estimate from station data. [2]Latest and earliest freezes recorded at 32° F. Average precipitation is a 30-year average (1961-1990) calculated from National Weather Service. Average temperature, latest freeze, earliest freeze, wind, and evaporation are for the same period calculated from station data.

TRANSITION FROM IRRIGATED TO DRYLAND CROPPING SYSTEMS[1]

by
Charles Norwood

SUMMARY

Corn yields from 1, 2, and 3 irrigations were 29%, 43%,and 62% higher, respectively, than dryland yields. Gross income averaged $296/acre when all acres were dryland. When all acres were irrigated once, gross income (less the cost of the irrigation water) was $370/acre. When one-half the acres were dryland and one-half were irrigated twice, gross income was $349/acre. When two-thirds of the acres were dryland and one-third was irrigated three times, gross income was $347/acre. Thus, during the time period of this study, irrigating all acres one time was the most profitable.

INTRODUCTION

Many producers are limiting irrigation because of the decline of the Ogallala aquifer and increasing energy costs. A reduction in irrigated area is expected to result in an increase in dryland cropping systems such as wheat-fallow and wheat-sorghum-fallow. Dryland crops produce only one-third to one-half the yield of irrigated crops. To slow the transition from irrigated to dryland acres, cropping systems that efficiently use both precipitation and irrigation water need to be developed. Continued irrigation, even if very limited, will allow the use of expensive irrigation systems already in place, and more importantly, will stabilize grain production in areas that otherwise would be returned to dryland. Therefore, a study was designed to compare dryland corn with corn irrigated one, two, or three times, with the objective of determining whether it is more profitable to irrigate a large acreage fewer times or a smaller acreage more times.

PROCEDURES

Garst 8714, a 105-day-maturity hybrid, was planted in early May of each year. Each irrigation consisted of 4 inches of water. One irrigation was done at tassel; two irrigations were done at tassel and grain fill; and three irrigations were done at vegetative, tassel, and grain fill. The cropping system used for all treatments was wheat-corn-fallow, which has 10- to 11-month fallow periods prior to each crop. The fallow period was used to store water and made preirrigation unnecessary. Conventional tillage (CT) and no-tillage (NT) treatments were compared. Target populations were 18,000 plants/acre for 0 and 1 irrigations and 24,000 plants/acre for 2 and 3 irrigations. Herbicides in the NT plots consisted of 2 lb/acre atrazine applied after wheat harvest followed by 1 lb/acre atrazine plus either 1.6 lb/acre Bladex or 2 lb/acre Dual applied as a tank mix shortly before planting. The CT plots received the same preplant herbicides, but sweep tillage was used for weed control during fallow instead of atrazine.

RESULTS AND DISCUSSION

Corn yield increased with irrigation, as expected (Table 1). Average responses to one, two, and three irrigations were 28, 14, and 19 bu/acre, respectively. The yield from two irrigations was significantly higher from that from one irrigation only in 1997. Yield from three irrigations was significantly higher than that from one irrigation in 1994, 1995, and 1997 and was greater than that from two irrigations in 1995. Thus, more response seemed to occur from irrigation during the vegetative (8 to 10 leaf) stage than from

[1]This research was funded in part by Kansas Corn Commission check-off funds.

Table 1. Effects of number of irrigations and tillage on corn yield, Garden City, KS, 1994-1997.

Number of Irrigations[1]	1994			1995			1996			1997			Average		
	CT	NT	Avg	CT	NT	Avg	CT	NT	Avg	CT	NT	Avg	CT	NT	Avg
	bu/acre														
0	103	120	112c	78	103	90c	108	118	113b	84	74	79c	93	103	98
1	141	150	146b	97	122	109b	120	130	125ab	119	132	126b	119	133	126
2	157	166	161ab	107	120	114b	124	137	130a	155	158	156a	136	145	140
3	178	170	174a	140	165	153a	128	149	138a	179	164	172a	156	162	159
Avg	145a[2]	152a		105b	127a		120b	133a		134a	132a		126	136	

[1]Each irrigation applied 4 inches of water.
[2]Means in a column or row within a year followed by a different letter differ at the 0.10 probability level.

one during grain fill. Corn responded to NT in 2 of 4 years, and average yield increased 10 bu/acre.

Table 2 shows gross income less the cost of irrigation water at $2.25/inch. Based on 4 years of results, the most income occurred when all acres were irrigated one time, whereas irrigating a reduced acreage more times usually produced less income. This particular experiment was flood irrigated; however, the results also can be applied to sprinkler irrigation. What the results do not illustrate is the importance of timeliness. A farmer with a low capacity well may not be able to flood irrigate all acres in a timely manner, i.e., when the crop is in the proper growth stage, whereas a farmer with a sprinkler probably can irrigate his acres faster. With limited water, the most important irrigation is the one at pollination; therefore, the amount of irrigated acres should be adjusted so that the corn is irrigated just prior to pollination. Any additional irrigation, up to the maximum economic return, should be considered a bonus.

Table 2. Gross income from combinations of irrigated and dryland corn, Garden City, KS, 1994-1997.

System	1994	1995	1996	1997	Avg.
			$/acre[1]		
100% dryland	336	270	339	237	296
100% irrigated once[2]	429	318	366	369	370
50% dryland, 50% irrigated twice	400	297	355	343	349
67% dryland, 33% irrigated three times	389	324	355	321	347

[1]Gross income minus irrigation water at $2.25/inch. Corn = $3.00/bu.
[2]Irrigated one, two, or three times means that 4, 8, or 12 inches of irrigation water, respectively, were applied.

YIELD OF NO-TILL DRYLAND CORN AS AFFECTED BY HYBRID, PLANTING DATE, AND PLANT POPULATION

by
Charles Norwood

SUMMARY

Dryland corn was grown in the wheat-corn-fallow rotation in 1996 and 1997 to compare hybrids, planting dates, and plant populations. Later planting produced better yields in both years. Yields generally increased with population and hybrid maturity in 1996 because of very favorable weather conditions. Yields from the early planting of all hybrids were low in 1997 because of dry July weather. Late-July rainfall greatly improved yields from the later planting date in 1997, sometimes more than 100%, but was too late to improve yields of the early planting. Higher populations improved yield of all later planted hybrids except the latest maturing (110 day) hybrid in 1997.

INTRODUCTION

The wheat-sorghum-fallow rotation produces more grain and is more profitable than the wheat-fallow rotation. A logical step up from wheat-sorghum-fallow is wheat-corn fallow. Corn traditionally is thought to lack sufficient heat and drought tolerance for dryland production in southwest Kansas. However, preliminary work at Garden City indicates that dryland corn can be feasible if attention is given to hybrid, planting date, and plant population. No-till has proven to be essential for adequate yields in dry years and has increased yields substantially in wet years. This no-till dryland corn study compares hybrids of five different maturities planted on two dates at three plant populations. The objectives of this study are to determine the corn maturity class, planting date, and plant population, or, more likely, a combination of these factors, that will allow successful dryland corn production in southwest Kansas.

PROCEDURES

Dryland corn was grown in a wheat-corn-fallow rotation in 1996 and 1997. Five Pioneer hybrids having days to maturity of 75, 92, 99, 106, and 110 were planted in mid-April and early May each year. The two earliest hybrids were not planted in 1996. Populations were 12000, 18000, and 24000 plants/acre. The hybrids were no-till planted into the stubble remaining from the previous wheat crop.

RESULTS AND DISCUSSION

Results are given in Table 1. Yields of hybrids in 1996 increased with plant population. The 110-day hybrid produced the most yield, particularly at the highest population. Yields were improved by later planting, probably because of more favorable weather conditions. Yields were improved greatly by later planting in 1997, sometimes more than 100%. Hybrids planted on the second date were able to take advantage of rainfall that came too late for the earlier planting. The 110-day hybrid again produced the most grain, but yields were reduced at the high population. The 75-day hybrid was the lowest yielding on both dates. It apparently did not have enough yield potential to utilize the more favorable weather conditions following the later planting date.

Early planting can increase irrigated corn yield and dryland yield, if no stress occurs. Under dryland conditions in western Kansas, however, yield is determined by weather conditions, and rainfall distribution is most important. The best yield will result from the planting date followed by the best rainfall distribution. Thus far in this study, that has been the later of the two planting dates, but this could

Table 1. Effects of hybrid, planting date, and plant population on dryland corn (wheat-corn-fallow rotation). Garden City, KS, 1996-1997.

		Planting Date			Planting Date		
Hybrid (days)	Population	4/16/96	5/8/96	Avg	4/17/97	5/6/97	Avg
	plants /acre	bu/acre					
3984(75)	12000	—	—		37	43	40
	18000	—	—		36	58	47
	24000	—	—		35	64	50
	Average	—	—		36	55	
3860(92)	12000	—	—		51	88	70
	18000	—	—		45	108	77
	24000	—	—		46	99	73
	Average	—	—		47	98	
3737(98)	12000	78	112	95	42	65	54
	18000	100	139	120	38	87	63
	24000	128	156	142	55	106	81
	Average	102	136		45	86	
3514(106)	12000	99	84	92	69	92	81
	18000	106	133	120	39	84	62
	24000	128	143	136	50	104	77
	Average	111	120		53	93	
3394(110)	12000	102	117	110	64	106	85
	18000	126	161	144	40	130	85
	24000	159	173	166	22	93	58
	Average	129	150		42	110	
Hybrid avg	12000	93	104		—	—	
	18000	111	144		—	—	
	24000	138	157		—	—	
LSD (0.10): Date within hybrid (averaged over populations)				7			19
Hybrid within date (averaged over populations)				8			17
Date within population (averaged over hybrids)				9			14
Population within date (averaged over hybrids)				9			11
Hybrid within population (averaged over dates)				—			16
Population within hybrid (averaged over dates)				—			14

change easily if good rainfall distribution follows the first date and poor distribution follows the second date. Yields also will increase with increasing maturity and higher plant populations, provided that enough rainfall occurs. However, higher populations use more soil water, or, at least, water is depleted faster than at a lower population. The results of dryland corn research done so far support a population of 18000 plants/acre, with the qualification that yields may be reduced in dry years compared with lower populations. The results of this and other studies also indicate that the yield reduction from too high a population in dry years is less than the yield reduction resulting from too low a population in wet years.

Based on this research, a farmer should plant two or more corn hybrids on more than one date, at populations not exceeding 18000 plants/acre. This recommendation will be revised in accordance with future research results.

YIELD OF DRYLAND CORN AS AFFECTED BY SLOPED VERSUS FLAT LAND

by
Charles Norwood

SUMMARY

Four corn hybrids ranging in maturity from 92 to 110 days were grown on sloped and flat land. Yield was unaffected by hybrid maturity. Yield on the slope averaged 27 bu/acre, whereas yield on flat land averaged 68 bu/acre.

INTRODUCTION

Dryland corn is not as drought and heat tolerant as grain sorghum. For dryland corn to yield well, particular attention needs to be given to hybrid maturity, planting date, and plant population. Because the yield of dryland corn depends on stored soil water and growing season rainfall, it probably should be planted where maximum accumulation of water can occur. This study was designed to compare the yield of corn grown on a slope with that grown on flat land.

PROCEDURES

Four Pioneer hybrids of 92-, 98-, 106-, and 110-day maturities were planted on sloped and flat plot areas in a wheat-corn-fallow rotation. The hybrids were no-till planted in the stubble remaining from the 1996 wheat crop on April 23, 1997. The target population was 18000 plants/acre. Actual populations were closer to 12000 plants/acre because of crusting.

RESULTS AND DISCUSSION

Yields are presented in Table 1. Growing season rainfall was above average, but rainfall distribution was poor, particularly in July. Yields were variable because of nonuniform stands and did not differ significantly between hybrids. Yields ranged from 31 to 53 bu/acre higher on the flat plot area. Average yields were only 27 bu/acre on the slope vs. 68 bu/acre on the flat plot area. Less water was stored during fallow on the sloped area and much of the rainfall ran off, reducing yield. However, water ran onto the flat area, increasing yield. Preliminary conclusions are that dryland corn should not be grown on land having much slope. In years of poor rainfall distribution, less water will be stored on a slope and much of the growing season rainfall will run off. Dryland corn should be planted on your best land.

Table 1. Yield of dryland corn on sloped vs flat land, Garden City, KS, 1997.

Hybrid (days to maturity)	Slope	Flat
	bu/acre	
Pioneer 3860 (92)	37	68
Pioneer 3737 (98)	32	73
Pioneer 3514 (106)	18	71
Pioneer 3394 (110)	20	60
Average	27	68
LSD ($p<0.10$)	ns	ns

NITROGEN FERTILIZATION OF DRYLAND WINTER WHEAT[1]

by

Alan Schlegel, Kevin Dhuyvetter[2], and John Havlin[3]

SUMMARY

Research was initiated in 1993 to determine the N fertilizer requirement for dryland winter wheat grown under reduced-tillage systems in western Kansas. Six sites in west central Kansas were selected each year for 4 years in cooperation with area farmers. The typical cropping system was wheat-fallow using reduced-tillage practices. All sites were on silt loam soil that ranged in residual soil nitrate content from less than 1 ppm (0- to 24-inch sample) to over 10 ppm. Surface residue cover at wheat planting averaged 30%. Fluid N (28% N as urea-ammonium nitrate solution) was spoke injected in the fall (September) and spring (March) and surface broadcast during the winter (January) and spring at five rates (20, 40, 60, 80, and 100 lb N/acre), and a zero N control was included. The typical production practice was planting TAM 107 winter wheat in mid-September with a hoe drill on 12-inch row spacing. Grain protein increased linearly with increased N rates. Grain protein was over 13% when 100 lb N/acre was injected. Nitrogen use efficiency decreased with increased N rates but was consistently higher with injected rather than broadcast N. The residue/yield ratio was 125 lb residue/bu of yield or higher, which is greater than the commonly used value of 100 lb residue/bu of grain yield. The soil N test was a good indicator of yield response to N fertilization. Grain yields were greater when N was injected rather than broadcast. The time of N application had little effect on grain yield. The economic optimal N rate was greater when N was injected than broadcast at all soil N levels because of higher yield levels. Compared to the current KSU N recommendation model, these data suggest that N rates should be increased by 15 to 30 lb/acre to optimize dryland wheat profitability.

INTRODUCTION

The N fertilizer recommendations for winter wheat in western Kansas were developed under clean tillage systems. In these systems, most of the residue is incorporated into the soil, leaving a seedbed with minimal residue cover. Current reduced-tillage systems emphasize conserving surface residue to reduce erosion potential and enhance soil water storage. However, crop residue on the soil surface can reduce the efficiency of N fertilizer utilization by plants especially with broadcast applications. This research was initiated to determine whether adoption of reduced-tillage systems has changed the N fertilizer requirements for dryland winter wheat in western Kansas.

PROCEDURES

Six sites in west central Kansas were selected each year for 4 years (1994-1997) in cooperation with area farmers. The typical cropping system was wheat-fallow using reduced-tillage practices. Residual soil N samples were taken in August prior to wheat planting. All sites were on silt loam soil that varied in residual soil nitrate content from less than 1 ppm (0- to 24-inch sample) to slightly over 10 ppm. Residual soil N in lb/acre was calculated as soil N in ppm times 7.5. Soil P levels were adequate at all sites. Surface residue cover at wheat planting averaged 30% (as measured by the line transect method) and ranged from less than 10% to greater than 50%.

Fluid N (28% N as urea-ammonium nitrate solution) was spoke injected in the fall (September) and spring (March) and broadcast during the winter (January) and spring at five rates (20, 40, 60, 80, and 100 lb N/acre), and a zero N control was included.

[1]This research was funded by the Kansas Fertilizer Fund.

[2]Northeast Area Extension Office, Kansas State University, Manhattan.

[3]North Carolina State University, Raleigh, NC.

The spoke applicator had 8 spokewheels (manufactured by Spoke Injector Systems, Inc., Lemberg, Saskatchewan) on 15-inch spacing (total width of 10 ft). The fluid N was delivered using a compressed air system mounted on the applicator. The spokewheels placed the fluid N about 2 to 3 inches into the soil with minimal disturbance. The broadcast applications were made using a 10-ft spray boom with 15-inch nozzle spacing and compressed air delivery of fluid N. Plot size was 10 by 40 ft. The experimental design was a randomized complete block replicated four times.

The farmer cooperators were responsible for tillage and planting operations, some variations occurred. The typical production practice was planting in mid-September with a hoe drill on 12-inch row spacing. The most common variety planted was TAM 107.

The center of each plot was combine harvested, and grain yields were adjusted to 12.5% moisture. The wheat at several sites was damaged by weather conditions (hail and a spring freeze), so only 13 site-years (out of 24 established) were included in the analysis. Aboveground biomass was collected from each plot at harvest, dried, and weighed. Residue was calculated as aboveground biomass minus grain yield. The residue/yield ratio was calculated as residue (lb/acre) divided by grain yield (bu/acre). Grain samples collected at harvest were analyzed for grain N content. Grain protein was calculated as grain N times 5.7. Apparent N use efficiency was calculated as the increase in grain N in treatments receiving fertilizer N over that of the control treatment divided by the fertilizer N rate. The data for residue, grain protein, and apparent N use efficiency are presented as averages across all site-years.

A regression equation was fitted to the yield information from all of the site-years; the independent variables were total N (residual soil nitrate + fertilizer N), surface residue cover, and method of application. The production function is:

grain yield = $12.2 + 0.2949N - 0.0012N^2 + 0.0654\ I\_N + 0.0234\ B\_N + 0.6299\ R - 0.0076\ R^2$ + year variables

where N = residual soil nitrate + fertilizer N, lb acre

I_N = injected N, lb/acre

B_N = broadcast N, lb/acre

R = surface residue cover at planting, %

with an R^2 of 0.3837.

The time of N application had little effect on grain yield and was not included in the regression equation.

When the yield function was estimated, the economic optimal N rates were calculated by equating the first derivative of the yield function to the fertilizer N/wheat price ratio and solving for N using the following two equations.

For broadcast N:

economic optimal N rate (lb/acre) = $[(P_n/P_w) - 0.3183 + (0.0024 \times \text{soil N})] / -0.0024$

For injected N:

economic optimal N rate (lb/acre) = $[(P_n/P_w) - 0.3603 + (0.0024 \times \text{soil N})] / -0.0024$

where P_n = price of N, $/lb

P_w = price of wheat, $/bu

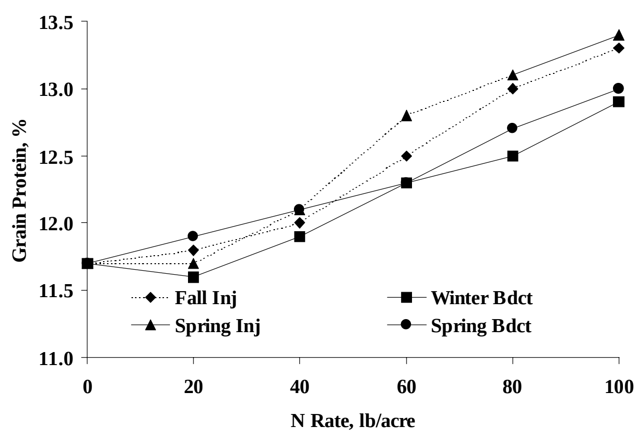
soil N = residual soil nitrate, lb/acre.

The economic optimal N rate depends on the price of N, the price of wheat, and residual soil nitrate content.

RESULTS AND DISCUSSION

Grain protein levels increased linearly with increased N rates (Fig. 1). Grain protein was greater with N fertilizer injected than broadcast and was over 13% when N fertilizer was injected at the higher rates. Apparent N use efficiency was greater when fertilizer N was injected rather than broadcast (Fig. 2). Apparent N use efficiency was over 30% with N injected in the spring at the lowest rates and tended to decrease as rates increased.

Fig. 1. Grain protein response to N fertilization (average of 13 site-years), west central Kansas.



The general assumption used for estimating residue production by wheat has been 100 lb residue/bu of yield. In this study, the residue production was considerably greater than this guideline. Without N, the ratio was 180 lb of residue/bu of grain yield (Fig. 3). This decreased to about 125 lb residue/bu of yield at the higher N rates. This shows that residue production, even with a semidwarf wheat like TAM 107, is greater than has been assumed. Fertilizer placement and time of application had little effect on the residue/yield ratio.

Fig. 2. Apparent N use efficiency of wheat as affected by N fertilization (average of 13 site-years), west central Kansas.

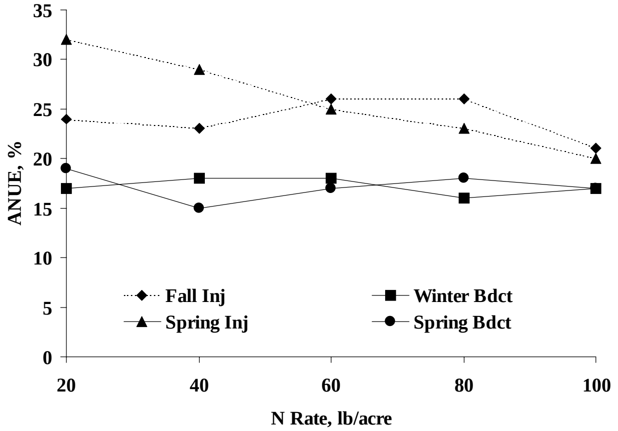


Fig. 4. Estimated wheat yields for injected and broadcast N fertilizer application with residual soil nitrate content of 25 lbs/acre, west central Kansas.

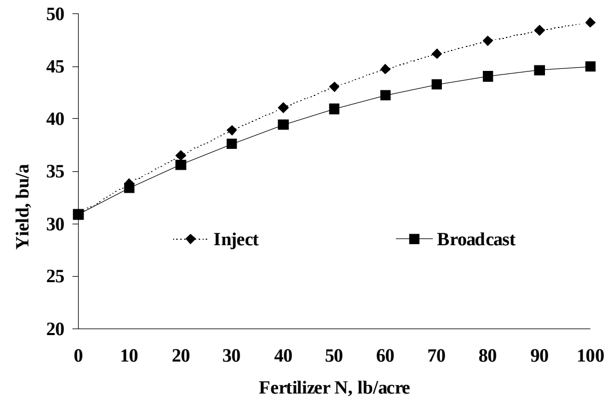


Fig. 3. The relationship of residue production and grain yield as affected by N fertilization (average of 13 site-years), west central Kansas.

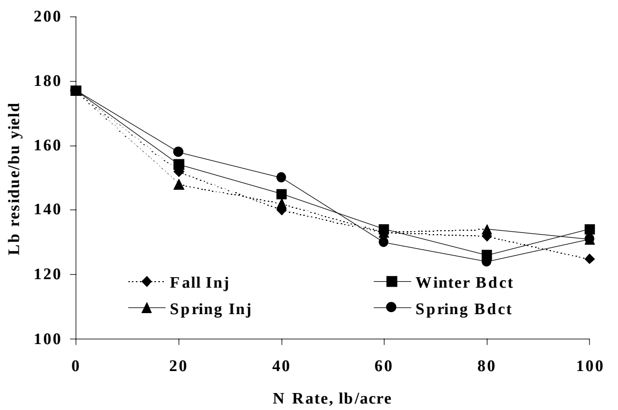
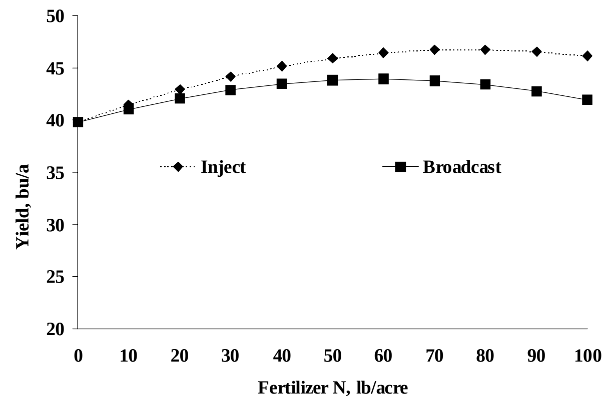


Fig. 5. Estimated wheat yields for injected and broadcast N fertilizer applications with residual soil nitrate content of 75 lb/acre, west central Kansas.



Grain yield was increased in most site-years by N fertilization. The amount of yield increase varied across site-years but increased with decreases in residual soil nitrate levels, indicating the value of a soil residual N test. At low levels of residual soil nitrate, the relative yield of the control treatment was generally less than 50% of the yield of the highest-yielding treatment. The time of N application had little effect on grain yield. Grain yields were similar from broadcast applications made in the winter and spring, indicating that topdress N applications can be made over a several-month period without affecting grain yield. Grain yields were also similar for injected N treatments made in the fall and spring, indicating that little N loss occurred from fall applications.

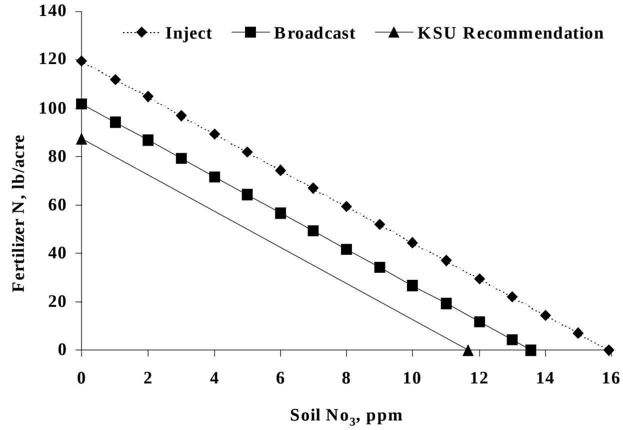
The yield production function was used to estimate yield responses to fertilizer N at two levels of residual soil N (Figs. 4 and 5). Grain yields were greater with injected rather than broadcast N at all residual soil N levels. The yield increase from injected N over broadcast N was not compensated for by increased rates of broadcast N. Grain yields increased up to the highest N rate when residual soil nitrate was below 50 lb/acre, indicating that the study should have included N rates greater than 100 lb N/acre. However, this is much greater than the rate of about 40 lb N/acre commonly applied by producers in the region.

The economic optimal fertilizer N rate was calculated for broadcast and injected N over a range of residual soil N levels (Fig. 6). In our example, we assumed a wheat price of \$3.25/bu and N cost of \$0.25/lb. Fertilizer N recommendations are greater with injected than broadcast applied N. Initially, this seems to contradict the higher N use efficiency with injected compared to broadcast N. However, the higher yield potential with injected N results in a higher fertilizer N recommendation. These N recommendation models were compared to the current KSU model, which in its simplest form is:

N rec (lb/acre) = (YGx1.75) - soil N
where
N rec = fertilizer N recommended, lb/acre
YG = yield goal, bu/acre
soil N = residual soil nitrate, lb/acre.

A yield goal of 50 bu/acre was assumed for our comparison. With these assumptions, the KSU model recommends 88 lb fertilizer N/acre when residual soil N is zero compared to recommendations of 102 lb/acre for broadcast N and 119 lb/acre for injected N using the models developed from this study. This suggests that fertilizer N should be applied at higher than currently recommended rates to optimize economic returns. The increases in N fertilizer recommendations would be about 15 lb/acre for broadcast and 30 lb/acre for injected applications.

Fig. 6. The economic optimal N rates for broadcast and injected N fertilizer (assuming wheat at $3.25/bu and N at $0.25/lb) compared to the current KSU N recommendation model (yield goal of 50 bu/acre), west central Kansas.



EFFECT OF TILLAGE INTENSITY IN A WHEAT-SORGHUM-FALLOW ROTATION

by
Alan Schlegel

SUMMARY

Grain yields of wheat and grain sorghum increased with decreased tillage intensity. Averaged across 8 years, wheat yields were 4 bu/acre and sorghum yields 19 bu/acre greater with no-till than with conventional tillage. The benefit of no-till compared to conventional tillage tended to increase over time. Residue cover at planting was affected by tillage intensity and was considerably greater at sorghum than at wheat planting. At sorghum planting, surface residue covers averaged 82% for no-till, 73% for reduced tillage, and 49% for conventional tillage. At wheat planting, surface residue covers were 40% for no-till, 26% for reduced tillage, and 15% for conventional tillage. Tillage intensity had little impact on soil organic matter when measured after 5 years; however, levels of soil organic matter were lower in the cropped systems than in native sod. Levels of soil organic matter, P, and K decreased and pH increased with soil depth. Tillage intensity had little effect on the distribution of nutrients within the soil profile.

INTRODUCTION

Reduced-tillage practices have been shown to increase grain yields in semi-arid regions. Adoption of no-till systems may further enhance crop productivity in western Kansas and maintain or improve soil quality. This study was initiated in Tribune to determine the impact of tillage intensity in a wheat-sorghum-fallow system on grain yield and organic matter content of soil.

PROCEDURES

The experimental design was a randomized complete block with three intensities of tillage (conventional, reduced, and no-till) in a wheat-sorghum-fallow system with all crops present each year. Plot size was 50 by 100 ft, and four replications were done. The study area had been broken out of native sod immediately prior to study establishment in 1989. The primary tillage implement was a sweep plow. The conventional tillage treatment was tilled as needed to control weed growth during the noncrop period, generally three to four tillage operations. In no-till, weed growth was controlled with herbicides during the noncrop period. Between wheat harvest and sorghum planting, atrazine, glyphosate, and 2,4-D were used for weed control. Glyphosate and 2,4-D were used for weed control from sorghum harvest to wheat planting. The reduced-tillage system used a combination of tillage and herbicides for weed control during the noncrop period. Herbicides were used for in-crop weed control in all tillage systems. The center of each plot was machine harvested, and grain yields were adjusted to 12.5% moisture. Aboveground biomass was collected at harvest, dried, and weighed. Residue was calculated by subtracting grain yield from aboveground biomass. Surface residue cover at planting was measured by the line transect method. Soil samples (depths of 0-2, 2-6, and 6-12 inches) were collected in the summer of 1994 and analyzed for pH and contents of P, K, and organic matter.

RESULTS AND DISCUSSION

Wheat yields were increased as tillage decreased when averaged across all years (Table 1). However, a significant year by tillage interaction occurred, and a benefit from reducing tillage intensity was not seen in all years. In the first 2 years, wheat yields were similar for all tillage systems. In the last 2 years, however, wheat yields were 10 to 18 bu/acre greater with no-till than conventional tillage. Wheat yields with reduced tillage was in between those of conventional and no-till.

Grain sorghum yields have varied considerably across years from less than 10 to over 100 bu/acre

Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 1990-1997.

Tillage	1990	1991	1992	1993	1994	1995	1996	1997	Mean
					bu/acre				
Conventional	28	16	26	43	48	49	16	34	33
Reduced	26	14	14	55	48	51	25	42	34
No-till	27	15	21	58	46	56	26	52	38
LSD $_{0.05}$	3	6	10	4	7	7	9	17	3
ANOVA									
Tillage	0.459	0.672	0.067	0.001	0.602	0.066	0.073	0.121	0.001
Year									0.001
Tillage x year									0.001

(Table 2). When averaged across all years, grain sorghum yields were 19 bu/acre greater with no-till than conventional tillage. Similar to wheat, a significant year by tillage interaction occurred. In the first 3 years, yields were similar for all tillage systems. Since then, however, grain sorghum yields have been significantly higher each year with reduced or no-till than with conventional tillage. For example, in the past 2 years, sorghum yields have been 33 bu/acre greater with no-till. This indicates that when reduced-tillage practices are adopted, yield increases may not become apparent for several years.

Residue cover at planting was affected by tillage intensity and was considerably greater at sorghum than at wheat planting. At sorghum planting, surface residue covers were 82% for no-till, 73% for reduced tillage, and 49% for conventional tillage (average of 1994 to 1997). At wheat planting, surface residue covers were 40% for no-till, 26% for reduced tillage, and 15% for conventional tillage.

The intensity of tillage can affect soil chemical properties, particularly soil organic matter content. In this study, however, tillage systems had little impact on soil organic matter when measured after 5 years (Table 3). Levels of soil organic matter were lower in the cropped systems than in native sod. Levels of soil organic matter, P, and K decreased and pH increased with soil depth. Tillage intensity had little effect on the distribution of nutrients within the soil profile.

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS , 1990-1997.

Tillage	1990	1991	1992	1993	1994	1995	1996	1997	Mean
					bu/acre				
Conventional	6	23	38	47	20	37	97	71	42
Reduced	8	39	41	83	38	54	117	94	59
No-till	6	39	27	68	57	59	119	115	61
LSD $_{0.05}$	5	18	15	11	9	5	12	33	5
ANOVA									
Tillage	0.444	0.110	0.118	0.001	0.001	0.001	0.007	0.044	0.001
Year									0.001
Tillage x year									0.001

Table 3. Effect of tillage intensity on crop residue at planting in a wheat-sorghum-fallow rotation, Tribune, KS, 1994-1997.

Tillage	1994	1995	1996	1997	Mean
	% residue cover at planting				
WHEAT					
Conventional	11	17	25	6	15
Reduced	26	31	31	15	26
No-till	41	52	54	15	40
LSD $_{0.05}$	5	22	13	5	6
<u>ANOVA</u>					
Tillage	0.001	0.022	0.005	0.009	0.001
Year					
0.001					
Tillage x year					0.034
GRAIN SORGHUM					
Conventional	54	57	58	26	49
Reduced	84	61	84	63	73
No-till	87	82	86	74	82
LSD $_{0.05}$	10	22	13	23	7
<u>ANOVA</u>					
Tillage	0.001	0.066	0.003	0.005	0.001
Year					0.011
Tillage x year					0.050

Table 4. Impact of 5 years of three tillage intensities in a wheat-sorghum-fallow rotation on soil properties compared to native sod, Tribune, KS.

Tillage	Depth	pH	Bray-1 P	K	Organic Matter
	inch		ppm	ppm	%
Conventional	0-2	6.7	58	843	3.2
	2-6	7.3	37	508	2.6
	6-12	7.6	22	453	1.8
Reduced	0-2	6.6	59	880	3.2
	2-6	7.2	38	504	2.6
	6-12	7.5	23	445	2.0
No-till	0-2	6.6	61	886	3.2
	2-6	7.2	38	523	2.7
	6-12	7.5	21	450	2.1
Native sod	0-2	6.8	44	579	3.7
	2-6	7.3	36	496	2.8
	6-12	7.6	28	460	2.2
ANOVA					
Tillage		0.068	0.817	0.490	0.088
Depth		0.001	0.001	0.001	0.001
Tillage x depth		0.863	0.837	0.682	0.534
Main effect means					
Tillage					
Conventional		7.2	39	601	2.5
Reduced		7.1	40	610	2.6
No-till		7.1	40	620	2.6
$LSD_{0.05}$		0.1	3	31	0.1
Depth					
0-2 inches		6.6	59	870	3.2
2-6		7.2	38	512	2.6
6-12		7.5	22	449	2.0
$LSD_{0.05}$		0.1	3	31	0.1

Native sod is not included in statistical analysis for ANOVA and main effect means.

BEST MANAGEMENT PRACTICES FOR RETURNING CONSERVATION RESERVE PROGRAM LAND TO WHEAT PRODUCTION

by
Alan Schlegel and Curtis Thompson

SUMMARY

The majority of the Conservation Reserve Program (CRP) acres in Kansas are in western part of the state. The contracts under the initial CRP are expiring and, if not re-enrolled in the CRP program, most of the acreage will be returned to crop production. This study was initiated in 1995 to evaluate best management practices for returning CRP land to crop production. The CRP grasses (mixed species, warm-season grasses) were difficult to control with herbicides alone, and good grass control is essential for optimum crop production. Wheat yields were considerably higher with conventional tillage than with no-till. Removal of the old residue by burning or mowing had no positive effect on wheat yields. Soil water content was very low following destruction of the CRP grasses. Sufficient time should be allowed between destruction of the CRP grasses and planting of the first crop for accumulation of soil water. Tillage initiation in the fall or spring had little effect on wheat yields, but fall tillage may be preferred because of drier soil conditions. Wheat yields were similar when the first tillage was done with a disk or sweep plow, although the disk was much easier to pull through the sod. Residual soil inorganic N levels are extremely low in CRP land, and supplemental fertilization of 100 lb N/acre or more was required for optimal wheat production.

INTRODUCTION

In Kansas, 2.9 million acres were enrolled in the Conservation Reserve Program (CRP) which was the third greatest participation by any state. The majority of the CRP acres in Kansas are in the western one-third of the state. Over 90% of the CRP land in Kansas is planted to grass. Based on past experience with an earlier land retirement program, the "Soil Bank", most acres planted to grass will return to crop production. The principal crop grown on land prior to enrollment in the CRP was winter wheat. With the expiration of CRP contracts, many of these acres will return to wheat production.

PROCEDURES

This study was initiated in the spring of 1995 in west central Kansas near Tribune. The study area was enrolled in the CRP and had an established stand of warm-season grasses. Primary species were sideoats grama, little bluestem, blue grama, buffalograss, and switchgrass, which were typical for the area. Soil type was a Richfield silt loam with less than 1% slope. Soil chemical properties were pH of 8.0, organic matter of 1.4%, and inorganic N content of 2 ppm nitrate in the surface 1 ft and less than 1 ppm in the 2 through 6 ft depth. The objectives of the project were to determine best management practices for returning CRP land to crop production. The variables evaluated were residue pretreatment (burn, mow, or leave standing); grass control methods (tillage or chemical control); and N fertilization. The burn treatments were done in late April 1995. The mow treatments were done in early July and late September 1995.

The no-till treatment for 1996-97 wheat received three applications of glyphosate (2 qt/acre) plus ammonium sulfate and surfactant (mid July 1995, early July 1996, and late August 1996). The conventional-tillage treatment was offset disked twice (July and August 1995) and sweep plowed four times (September 1995, June, July, and September 1996). The reduced-tillage treatment received one application of glyphosate (2 qt/acre) plus ammonium sulfate and surfactant in July 1995 and then was offset disked in August 1995 and sweep plowed once in September 1995 and three times in 1996 (June, July, and September). Winter wheat was planted on September 13, 1996 with starter fertilizer (100 lb/acre of 11-52-0 applied with the seed). Stand establishment was adequate in all treatments. Fertilizer N (as urea) was applied in December at rates of 50, 100, and 150 lb N/acre; one plot received no N.

A second wheat study evaluated the time of tillage initiation and the type of tillage. Tillage was initiated either in the fall or spring with either a disc or sweep plow. For spring tillage initiation, the residue was burned or left standing.

RESULTS AND DISCUSSION

CRP grass control ratings were taken in early September 1996 prior to planting of winter wheat. The warm-season grasses were eliminated by conventional tillage and 90% controlled in no-till. With reduced tillage, grass control was 90% when the residue had been burned but only about 70% when the residue had been mowed. Very little grass was present in any treatment in the spring of 1997.

Wheat yields were much better where the grass was controlled with tillage than with herbicides (Table 1). With reduced tillage, grain yields were intermediate between those of conventional and no-till. Neither mowing nor burning the residue prior to tillage/chemical application had much effect on grain yield.

Initiating tillage in the fall after contract expiration or waiting until spring had little effect (Table 2). However, the ground was drier in fall than in spring, which made the tilling easier. Burning the residue before tillage and using a disk or sweep plow for the initial tillage had little effect on wheat yield. However, pulling the sweep plow through the field and maintaining an even depth were extremely difficult.

Nitrogen applications improved grain yield in both wheat studies. Grain yields averaged across all treatments with 150 lb N/acre were three times greater than yield of the control. All tillage and residue treatment combinations responded to N application. The increase from 100 to 150 lb N/acre increased yield 5 bu/acre. Although this would be marginally profitable, it indicates that the system was deficient in N, and high supplemental N rates will be required for yields comparable to other cropped land.

Acknowledgments: We thank Ross Kuttler for providing the land for this study and the other participants: the Natural Resource Conservation Service, Monsanto, and Farm Journal.

Table 1. Winter wheat yields on former CRP land near Tribune, KS as affected by residue management tillage and N fertilization, 1997.

Treatment		Nitrogen Rate (lb/acre) 0	50	100	150	Mean
		bu/acre				
Mow	Conv. till	17	29	37	40	31
Mow	Reduced till	10	18	31	30	22
Mow	No-till	8	17	27	32	21
Burn	Conv. till	16	27	34	37	29
Burn	Reduced till	12	23	28	33	24
Burn	No-till	4	15	21	28	17
LS	Conv. till	24	30	36	44	33
LS	No-till	7	16	28	34	21
Mean		13	23	30	35	25

$LSD_{0.05}$ treatment=8, N rate=2

Table 2. Winter wheat yields on former CRP land near Tribune, KS as affected by time and kind of tillage and N fertilization, 1997.

Treatment	Nitrogen Rate (lb/acre) 0	50	100	150	Mean
	bu/acre				
Fall - Leave residue stand					
Disc	10	21	25	31	22
Sweep	8	17	26	31	21
Spring - Leave residue stand					
Disc	8	18	27	33	22
Sweep	11	18	26	32	22
Spring - Burn residue					
Disc	9	17	26	34	21
Sweep	10	17	30	34	23
Control	1	6	8	11	6

$LSD_{0.05}$ treatment=10, N rate=2

The tillage treatments listed were the initial tillage performed. All treatments also received a second tillage operation (either disc or sweep) and then all treatments received two sweep plow operations during the summer of 1996.

ROOT ZONE SALINITY RESULTING FROM SUBSURFACE DRIP IRRIGATION WITH SALINE GROUNDWATER

by
Todd Trooien

SUMMARY

This study determined the level of salt present in the root zone (the top 8 ft of the soil profile) after 7 years of subsurface drip irrigation with saline groundwater. Two plots receiving different amounts of water were sampled after corn harvest in 1996. The lowest salinity was present at shallow depths 15 and 30 in. from the dripline. Values generally were higher in the more-irrigated plot. Soils below 36 in. were saline in both plots. However, salinity levels in the top 36 in. of the less-irrigated plot and from 6 in. to 48 in. of the more-irrigated plot were below the threshold for reducing corn yield. Proper management of irrigation and leaching is needed to prevent further increases in salinity.

INTRODUCTION

Groundwater has become saline in a corridor along the Arkansas River in southwest Kansas. Because this saline water is used for irrigation and will continue to be, management strategies must be identified to minimize the impact of that salinity on crop yields and soil conditions. Before developing areawide management strategies, the actual salt content in the soil profile resulting from irrigation with the saline water should be measured.

In 1990, Kansas State University established a site near Holcomb to study subsurface drip irrigation (SDI). Research at this site and elsewhere has shown that SDI is a water-efficient technology, giving the irrigator the opportunity to reduce the amount of water pumped with no loss of yield. The site is located near the Arkansas River, and the groundwater used for irrigation at the site is saline. We do not know how the use of SDI with saline groundwater will affect the salt balance in the root zone of row crops in western Kansas. Therefore, the objective of this study was to measure the amount of salt present in the top 8 ft of the soil profile after 7 years of SDI with saline groundwater.

PROCEDURES

The soil is Richfield silt loam. The area was furrow irrigated prior to the beginning of research in 1990.

The SDI driplines were placed 17 in. deep and 60 in. apart. The dripline was a twin-wall tape and has a flow rate of 0.25 gpm/100 ft. Tillage was used to create beds 60 in. apart, with the dripline located beneath the bed. Corn rows were planted on the sides of the beds such that each corn row was 15 in. from the nearest dripline. Machine traffic was limited to the furrows between the driplines.

Two plots were sampled following corn harvest in 1996. The "more-irrigated" plot received a relatively large amount of irrigation water during the growing seasons of the first 7 years (Table 1). The "less-irrigated" plot received less irrigation water. Additionally, some water was added to the plots during winter months to test the performance of the irrigation system. Corn has been grown at the site each year since establishment.

Table 1. Inches of irrigation water applied to the sampled plots, Holcomb, KS.

Plot	1990	1991	1992	1993	1994	1995	1996	Total
More irrigated	11.25	11.25	5.35	21.31	14.41	12.02	10.72	86.31
Less irrigated	0.00	7.50	9.23	0.83	14.74	12.15	7.65	52.09

Samples were taken in 6 in. increments from 0 to 24 in. then in 12-in. increments to a depth of 96 in. Samples were collected at four distances from the dripline: 0 in. (adjacent to the dripline), 6 in., 15 in. (in the corn row), and 30 in. (halfway between driplines). Each sample was the composite of three soil cores.

Each sample was dried and ground. The electrical conductivity of the saturated paste extract (EC_e) was measured for each sample. The EC_e measures the total amount of soluble salts present in a soil sample.

RESULTS AND DISCUSSION

The irrigation water used at the research site is classified as very poor quality irrigation water because of high salinity and sodium content (Table 2). The EC_e of the irrigation water is quite high, presenting the potential for salt accumulation in the root zone and consequent yield reduction from salt (osmotic) stress. If water of this sodium content were applied with a sprinkler system, a fine-textured soil would be prone to dispersion at the surface, causing reduction of infiltration rate. However, the high EC_e tends to counteract or prevent some of the sodium-induced soil dispersion. Sulfate is the ion of greatest concentration in this water.

A significant amount of salt was present in the soil profile of these plots (Table 3). The salinity was the lowest at shallow depths 15 and 30 in. from the dripline. Less irrigation water reaches these locations, so precipitation plays a much greater role in the water balance. They also are located in the furrow of the KSU SDI bed system, so precipitation will accumulate and effect greater salt leaching. The greatest amount of salt in the less-irrigated plot was present 15 in. from the dripline at lower depths. The greater leaching directly beneath the dripline helps flush some of the salts downward and keep the EC_e lower. At 15 in. from the dripline the top 24 in. of the root zone was still nonsaline in the less-irrigated plot, whereas the top 6 in. of the more-irrigated plot was saline. At depths greater than 36 in. of the crop row in both plots, the soil was saline. The roots in the crop row kept the soil dry, so leaching below 36 in. was reduced.

Table 2. Selected parameters of the irrigation water by date of sample, Holcomb, KS.

Parameter	9/92	9/93	11/94	10/95	9/96
EC_e, mmho/cm	4.4	4.7	4.9	4.7	4.2
Sulfate, ppm	1647	1602	1762	1612	1112
SAR_e	2.7	2.7	2.8	2.9	2.8
pH	7.3	7.3	7.5	7.2	7.6

EC_e: Electrical conductivity of a soil saturated paste extract.
SAR_e: Sodium adsorption ratio of a soil saturated paste extract.

Table 3. Electrical conductivity of the saturated extract, mmho/cm, SDI study, Holcomb, KS.

	More-Irrigated Plot (Distance from dripline, in.)				Less-Irrigated Plot (Distance from dripline, in.)			
Depth, in.	0	6	15	30	0	6	15	30
0-6	1.85	1.72	1.92	0.25	1.70	1.25	0.35	0.36
6-12	1.33	1.56	1.19	0.29	1.92	1.54	0.33	0.50
12-18	1.11	1.19	1.00	0.42	1.28	1.33	0.35	0.61
18-24	1.04	1.00	1.11	0.63	1.14	1.05	0.59	0.67
24-36	1.06	1.00	1.52	0.87	1.03	1.06	1.11	0.74
36-48	1.09	1.52	2.08	1.45	1.00	1.11	1.56	1.28
48-60	1.56	1.82	2.17	1.43	1.00	1.41	1.89	1.56
60-72	2.11	2.00	1.67	1.72	1.39	1.25	1.70	1.32
72-84	1.96	1.56	1.61	1.70	1.05	1.22	1.43	1.72
84-96	1.85	1.39	1.54	1.39	1.12	1.16	1.28	1.28

Previously published salinity reports suggested that reductions in corn grain yield begin at about 1.7 mmho/cm. Salinity in a part of the root zone in each plot is at or above this level. However, water uptake by corn can occur in less-saline areas of the root zone and thereby avoid yield-reducing salt stress. Because the top 36 in. of the less-irrigated plot and the top 48 in. (except the top 6 in.) of the more-irrigated plot have EC_e less than the 1.7 mmho/cm threshold, yield reductions from salt stress probably are not occurring. But they could happen at some time in the future, if more salts accumulate in the root zone, especially in the more-irrigated plot because of the high salinity at the soil surface. Without proper leaching management, irrigation with water such as used in this study could easily cause salinity levels in the root zone to increase further and reduce yield.

CONCLUSIONS

The top 96 in. of the soil profile at the SDI experiment site show signs of salinity accumulation and potential for crop yield reduction if not managed carefully. Two apparently conflicting objectives must be balanced to prevent harmful salt accumulation. Thrifty management of irrigation water will help minimize the total amount of salts added to the soil. On the other hand, leaching, which requires either overirrigation or timely and plentiful rainfall, will be required to help move excess salts downward and out of the root zone.

CORN BORER RESISTANCE OF BT AND NON-BT CORN HYBRIDS WITH THE AGREVO CBH-351 EVENT, GARDEN CITY AND ST. JOHN, KANSAS, 1997

by

Larry Buschman, Phil Sloderbeck, Yu-jie Guo[1], and Victor Martin[2]

SUMMARY

Corn hybrids from Garst Seeds and Holden's Foundation Seeds, Inc. with the new Bt event, CBH-351, and other Bt and non-Bt hybrids were evaluated for corn borer resistance at Garden City and St. John. Control of European and southwestern corn borer was superior for CBH-351 and Bt-11 hybrids. Corn borer control for the Bt-176 hybrid was similar to that achieved with two applications of Warrior™.

INTRODUCTION

The new corn borer-resistant Bt corn hybrids have shown outstanding resistance to the European corn borer (ECB), *Ostrinia nubilalis* (Hübner), and the southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar. Kernel damage caused mostly by the corn earworm (CEW), *Helicoverpa zea* (Boddie), also has been suppressed. Bt corn has been genetically engineered to express the delta endotoxins originally isolated from the bacterium, *Bacillus thuringiensis.* Corn hybrids with Cry1Ab (Bt11, MON810 and Bt176) have been tested for several years. Hybrids with Cry1Ac (DeKalb) will be commercially available in 1998. The following trials were conducted to evaluate the new Cry9C (CBH-351) event from AgrEvo for corn borer resistance. Corn hybrids from Garst Seed Co. and Holden's Foundation Seeds, Inc., which include this new event, were evaluated.

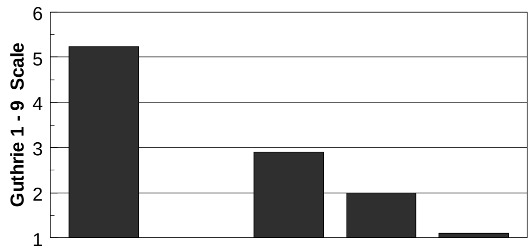
PROCEDURES

The corn hybrids were machine planted at Southwest Research-Extension Center near Garden City, KS, on 17 June at 30,000 plants/acre and at the Sandyland Experiment Field near St. John, KS, on 20 June at 26,000 plants/acre. The plots were two rows wide (30 in.) with two border rows of Bt11 corn planted between each plot. The plots were 20 ft long with alleyways 10 feet wide. The border rows and alleyways were included to reduce larval migration between plots. The experimental design was a randomized complete block with four replications. Two treatments were sprayed once or twice with Warrior™ 0.04 lb AI/acre using a 2.5-gal hand sprayer. The sprayer was calibrated to deliver 160 gal/acre at 20 to 40 psi with a fan-tip nozzle. At this delivery rate, some spray ran off into the leaf axials. The plots were sprayed on 4 & 30 Aug. at Garden City and on 1 & 25 Aug. at St. John. All corn borer infestations were natural.

The corn was planted after the first corn borer flight, but the early second-generation flight began while the corn was in the late whorl stage. Heavy shot-hole damage occurred at St. John in the susceptible hybrids, so this was rated using the Guthrie 1-9 scale. Data for second generation corn borers were taken from five consecutive plants in one row of each plot. The plants were dissected to measure corn borer tunneling and record the number and species of corn borer. Kernel damage (mostly by CEW), was recorded as the percentage of kernels damaged on each ear. Stalk rot ratings were recorded as the number of internodes at the base of the plant affected by stalk rot but did not include stalk rot associated with corn borer tunneling. At St. John, two samples were taken: on 1 & 2 Sept., when the larvae were small and tunneling was just beginning, and on Oct. 1 & 2, after larvae were mature, and tunneling was complete. At Garden City, samples were taken on 20 & 21 Oct. Yield was not determined on this very late-planted corn.

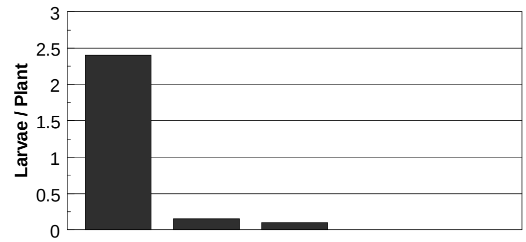
[1]Former visiting Research Scientist, Department of Entomology, Kansas State University, Manhattan.
[2]Sandyland Experiment Field, Kansas State University, St. John.

Fig. 1. Corn borer feeding damage in whorl-stage corn containing Bt176, Bt11, and Bt351 versus non-Bt-corn at St. John, KS.



CB Treatment	Std. Corn	N/A	Bt176	Bt11	Bt351
St. John ■	5.24		2.90	2.00	1.10

Fig. 2. Southwestern corn borer larvae found in corn containing Bt176, Bt11, nd Bt351 versus sprayed and unsprayed non-Bt-corn at St. John, Kansas, Sept. 1997.



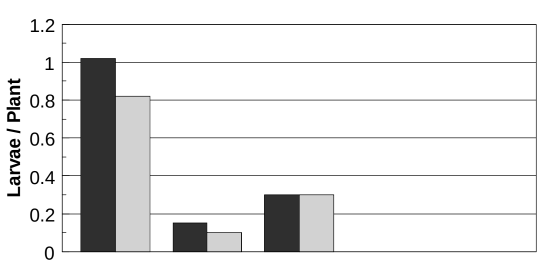
CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John ■	2.40	0.15	0.10	0.00	0.00

RESULTS AND DISCUSSION

Corn borer pressure was very high. At St. John, nearly every leaf had SWCB eggs and every plant had an ECB egg mass during early August. Whorl damage to the non-Bt corn was extensive, averaging over 5 on the 1-9 Guthrie scale (Table 1 and Fig. 1). The sprayed plots had not yet been sprayed and were included as standard corn. All three Bt events reduced whorl-stage damage to low levels, but significant differences occurred between them. The CBH-351 event hybrids usually lacked even pinhole damage (rating of 1.0), whereas the Bt11 event hybrid consistently had very small pinhole damage (rating of 2.0). While making these corn borer evaluations, we observed scattered plants with extensive feeding damage among all hybrids, including Bt11 and CBH-351. This damage was determined to be associated with feeding by fall armyworms, *Spodoptera frugiperda* (J.E. Smith).

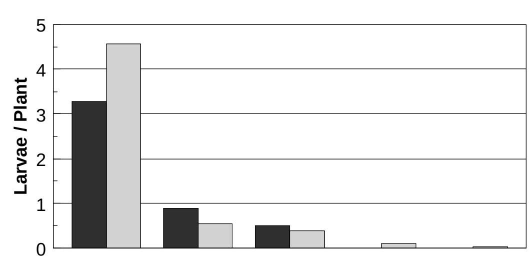
Second-generation SWCB pressure was heavy at both locations. At St. John, SWCB averaged 2.4 larvae per plant in the non-Bt hybrids in the September sample and 1.02 larvae per plant in the October sample (Tables 1 & 3, Figs. 2 & 3). At Garden City, SWCB pressure averaged 0.82 larvae per plant in the non-Bt hybrids in the October sample (Tables 1 & 3, Fig. 3). Second generation ECB pressure was also heavy at both locations. In the October samples, ECB pressure averaged 3.28 larvae per plant at St. John and 4.56 larvae per plant at Garden City in the non-Bt hybrids (Tables 1 & 3, Fig. 4). Corn borer control for Bt11 and CBH-351 was outstanding at both locations, with ratings of near zero throughout. At St. John, corn borer numbers in the September samples were almost as low in the Bt176 and Warrior-treated plots as they were in the Bt11 and CBH-351 plots (Fig. 2). However, in the October samples at both locations, corn borer numbers were significantly higher in the Bt176 and Warrior-treated plots than in the Bt11 and HFS-351 plots (Fig. 3 & 4). At St. John, the Holden CBH-351 had a small number of corn borer-infested plants (7 out of 198 plants). The larvae looked healthy, so the plants were probably non-Bt plants

Fig. 3. Southwestern corn borer larvae found in corn containing Bt176, Bt11, and Bt351 versus sprayed and unsprayed non-Bt-corn at St. John and Garden City, KS, Oct. 1997.



CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John ■	1.02	0.15	0.30	0.00	0.00
Garden City □	0.82	0.10	0.30	0.00	0.00

Fig. 4. European corn borer larvae found in corn containing Bt176, Bt11, and Bt351 versus sprayed and unsprayed non-Bt-corn at St. John and Garden City, KS, Oct. 1997.



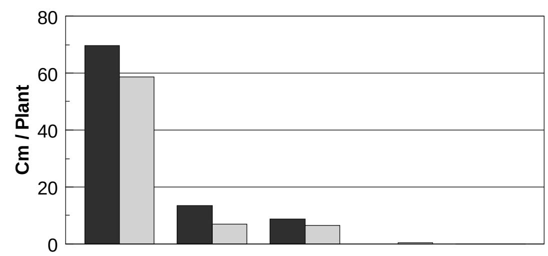
CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John ■	3.28	0.90	0.50	0.00	0.00
Garden City □	4.56	0.55	0.40	0.10	0.03

(nonexpressers). The other CBH-351 and Bt 11 plots had zero plants infested.

Corn borer tunneling damage was also extensive at both locations in the non-Bt hybrids. In the October samples, stalk tunneling averaged 69.8 cm per plant at St. John and 58.7 cm per plant at Garden City (Tables 2 & 3, Fig. 5). Shank tunneling averaged 1.26 cm per plant at St. John and 2.88 cm per plant at Garden City (Tables 2 & 3, Fig. 6). Corn borer control for Bt11 and CBH-351 hybrids was outstanding at both locations, with mean tunneling near zero throughout. The control for these events was significantly better than the control with Warrior spray or Bt176.

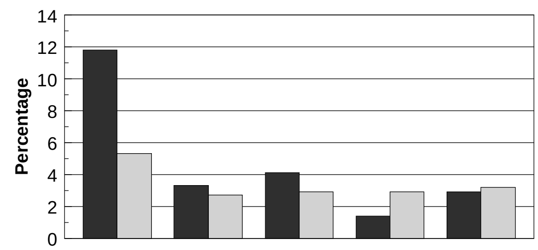
Kernel damage, mostly caused by corn earworm, averaged 11.8%, at St. John and 5.3% at Garden City in the non-Bt hybrids (Tables 2 & 3, Fig. 7). It appeared to be suppressed to a similar extent by all four corn borer treatments. Stalk rot ratings did not appear to be affected by the corn borer treatments; however, some significant differences occurred among hybrids (Tables 2 & 3, Fig. 8).

Fig. 5. Corn borer stalk tunneling found in corn containing Bt176, Bt11, and Bt351 versus sprayed and unsprayed non-Bt-corn at St. John and Garden City, KS, Oct. 1997.



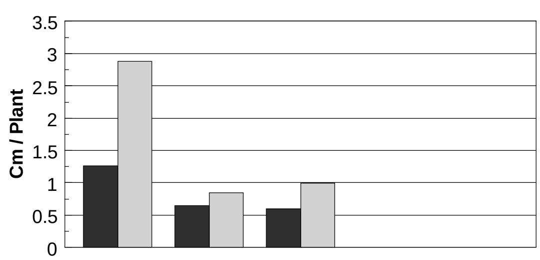
CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John	69.80	13.40	8.80	0.00	0.07
Garden City	58.70	6.90	6.40	0.50	0.07

Fig. 7. Kernel damage found in corn containing Bt176, Bt11, and Bt351 versus sprayed and unsprayed non-Bt-corn at St. John and Garden City, KS, Oct. 1997.



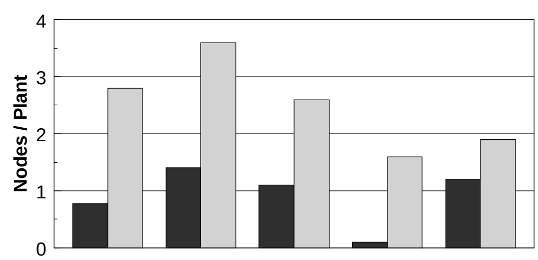
CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John	11.8	3.3	4.1	1.4	2.9
Garden City	5.3	2.7	2.9	2.9	3.2

Fig. 6. Corn borer shank tunneling found in corn containing Bt176, Bt11, and Bt351 versus sprayed and unsprayed non-Bt-corn at St. John and Garden City, KS, Oct. 1997.



CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John	1.26	0.65	0.60	0.00	0.00
Garden City	2.88	0.85	1.00	0.00	0.00

Fig 8. Nodes of stalk rot found in corn containing Bt176, Bt11, and Bt351 versus sprayed and unsprayed non-Bt-corn at St. John and Garden City, KS, Oct. 1997.



CB Treatment	Std. Corn	Spr. Corn	Bt176	Bt11	Bt351
St. John	0.78	1.40	1.10	0.10	1.20
Garden City	2.80	3.60	2.60	1.60	1.90

Table 1. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids at St John, KS, 1997.

Hybrid	Bt Status	Seed Company	Insecticide Treatment Warrior 0.04 lb/a	Whorl Damage 1-9 scale	SWCB Larvae Sept.	SWCB Larvae Oct.	SWCB Infested plants/ 5 plants	ECB Larvae Sept.	ECB Larvae Oct.	ECB Infested plants/ 5 plants
1. Exp83Bt	CBH-351	Garst/ICI	—	1.1 f	0.0 d	0.0 b	0.0 d	0.0 e	0.0 d	0.0 d
2. Exp83	—	Garst/ICI	—	4.9 c	2.8 ab	1.0 a	3.8 b	2.7 ab	4.0 a	4.5 a
3. Exp83	—	Garst/ICI	1X	5.0 bc	0.2 d	0.3 b	1.5 c	0.5 de	1.1 cd	3.0 b
4. Exp83	—	Garst/ICI	2X	4.8 c	0.1 d	0.0 b	0.0 d	0.4 de	0.7 cd	1.8 c
5. Exp86Bt	CBH-351	Garst/ICI	—	1.2 f	0.0 d	0.0 b	0.0 d	0.0 e	0.0 d	0.0 d
6. Exp86	—	Garst/ICI	—	5.1 abc	2.8 a	1.0 a	4.5 ab	3.4 a	3.4 ab	4.8 a
7. HSF-351	CBH-351	Holden	—	1.1 f	0.0 d	0.0 b	0.0 d	0.2 e	0.0 d	0.0 d
8. HSF	—	Holden	—	5.2 abc	2.2 b	1.1 a	4.8 ab	2.2 bc	3.0 ab	4.8 a
9. Max454	Bt176	Novartis	—	2.9 d	0.1 d	0.3 b	1.3 c	0.0 e	0.5 cd	2.3 bc
10. 4494	—	Novartis	—	5.6 a	2.6 ab	1.1 a	5.0 a	1.8 bc	4.2 a	4.8 a
11. N7639	Bt11	Novartis	—	2.0 e	0.0 d	0.0 b	0.0 d	0.0 e	0.0 d	0.0 d
12. N7931	—	Novartis	—	5.4 ab	1.6 c	0.9 a	4.3 ab	1.1 cd	1.8 bc	4.0 a
% CV	—	—	—	10	44	44	37	68	71	26
P-value				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Means separated using DMRT, P=0.05

Table 2. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids at St John, KS, 1997.

Hybrid	Bt Status	Seed Company	Insecticide Treatment Warrior 0.04 lb/a	CEW Larvae Sept.	CEW Instar Sept.	Kernel Damage Sept. %.	Kernel Damage Oct. %	Tunnel Length Stalk cm/plt	Tunnel Length Shank cm/plt	Stalk Rot nodes/ plant
1. Exp83Bt	CBH-351	Garst/ICI	—	2.9 ab	3.5 de	0.9 a	3.2 d	0.0 b	0.0 c	1.0 abc
2. Exp83	—	Garst/ICI	—	1.9 cd	4.1 abc	8.1 ef	11.8 c	60.9 a	1.3 ab	0.5 bc
3. Exp83	—	Garst/ICI	1X	1.5 d	4.3 a	1.1 ab	4.2 d	16.8 b	0.7 c	1.5 ab
4. Exp83	—	Garst/ICI	2X	1.9 bcd	3.9 abcde	1.7 ab	2.4 d	10.0 b	0.6 c	1.3 ab
5. Exp86Bt	CBH-351	Garst/ICI	—	2.5 abc	3.8 abcde	3.5 bc	3.5 d	0.0 b	0.0 c	2.0 a
6. Exp86	—	Garst/ICI	—	2.2 bcd	3.4 e	4.8 cd	5.9 cd	68.4 a	1.9 a	0.9 abc
7. HSF-351	CBH-351	Holden	—	2.1 bcd	3.5 bcde	0.9 a	2.0 d	0.2 b	0.0 c	0.5 bc
8. HSF	—	Holden	—	2.4 abcd	4.0 abcde	10.0 f	14.8 ab	72.8 a	1.0 b	1.1 abc
9. Max454	Bt176	Novartis	—	2.5 abc	3.5 cde	1.8 ab	4.1 d	8.8 b	0.6 bc	1.1 abc
10. 4494	—	Novartis	—	2.1 bcd	4.0 abcd	10.0 f	18.2 a	77.6 a	1.2 ab	0.5 bc
11. N7639	Bt11	Novartis	—	1.9 bcd	2.5 f	0.3 a	1.4 d	0.0 b	0.0 c	0.1 c
12. N7931	—	Novartis	—	3.2 a	4.2 ab	6.5 de	8.3 cd	69.3 a	0.9 b	0.9 abc
% CV	—	—	—	26	11	41	63	40	83	78
P-value				0.022	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Means separated using DMRT, P=0.05

Table 3. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids at Garden City, KS, 1997.

Hybrid	Bt Status	Seed Company	Insecticide Treatment Warrior 0.04 lb/a	SWCB Larvae Oct.	SWCB Infested plt/ 5 plant	ECB Larvae Oct.	ECB infest plt/ 5 plants	Kernel Damage Oct. %	Tunnel Length Stalk cm/plt	Tunnel Length Shank cm/plt	Stalk Rot nodes/ plant
1. Exp83Bt	CBH-351	Garst/ICI	—	0.0 b	0.0 b	0.0 d	0.0 d	3.0 cde	0.0 d	0.0 e	1.7 c
2. Exp83	—	Garst/ICI	—	0.7 a	3.5 a	5.3 ab	4.8 a	4.1 b-e	60.8 a	4.1 ab	3.8 ab
3. Exp83	—	Garst/ICI	1X	0.2 b	1.0 b	1.1 d	3.8 b	2.9 cde	13.1 c	1.4 cde	3.1 abc
4. Exp83	—	Garst/ICI	2X	0.0 b	0.0 b	0.0 d	1.3 c	2.4 de	0.6 d	0.3 e	4.0 a
5. Exp86Bt	CBH-351	Garst/ICI	—	0.0 b	0.0 b	0.1 d	0.3 d	4.5 a-e	0.2 d	0.0 e	1.8 bc
6. Exp86	—	Garst/ICI	—	1.0 a	4.5 a	5.7 a	4.8 a	5.2 abc	64.0 a	4.6 a	2.0 abc
7. HSF-351	CBH-351	Holden	—	0.0 b	0.0 b	0.0 d	0.0 d	2.2 e	0.0 d	0.0 e	2.3 abc
8. HSF	—	Holden	—	0.7 a	3.5 a	4.7 abc	4.75 a	4.7 a-d	62.3 a	2.7 bc	3.4 abc
9. Max454	Bt176	Novartis	—	0.3 b	1.3 b	0.4 d	1.3 c	2.9 cde	6.4 cd	1.0 cde	2.6 abc
10. 4494	—	Novartis	—	0.8 a	3.8 a	3.3 c	4.5 ab	6.0 ab	45.1 b	2.3 cd	1.4 c
11. N7639	Bt11	Novartis	—	0.0 b	0.0 b	0.1 d	0.3 d	2.9 cde	0.5 d	0.0 e	1.6 c
12. N7931	—	Novartis	—	0.9 a	4.5 a	3.8 bc	5.0 a	6.5 a	61.1 a	0.7 de	3.2 abc
% CV	—	—	—	49	49	50	20	36	31	79	47
P-value				<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.041

Means separated using DMRT, P=0.05

CORN BORER RESISTANCE AND GRAIN YIELD OF BT AND NON-BT CORN HYBRIDS AT ST. JOHN, KS, 1997[1]

by
Larry Buschman, Phil Sloderbeck, Yu-jie Guo, and Victor Martin

SUMMARY

Fifteen corn hybrids (six Bt- and nine non-Bt-corn) were evaluated for corn borer resistance and grain yield performance. All of the Bt hybrids were very effective at controlling first-generation corn borer damage. Second-generation corn borer damage to posttassel corn was dependent on the Bt event. Hybrids with the Bt11 and MON810 events gave superior levels of control and appeared to have very good yield potential.

PROCEDURES

Corn hybrid plots were machine planted on 7 May at 26,000 seeds/acre at the Sandyland Experiment Field near St. John, KS. Spot replanting was done as necessary to fill in gaps in the plots, and because of an error, some plots might have contained a few off-type plants (average of 3-5). Most of these were excluded during the corn borer evaluations by avoiding unusually small plants, but they were included in the yield calculations. The plots were hand thinned to a target stand of about 45 plants per row. The plots were four rows wide (10 ft) by 30 ft long with two rows (5 ft) of Bt corn planted between the plots as border rows and 10 ft alleyways at the end of each plot. The border rows and alleyways were included to reduce larval migration between plots. The experimental design was a split-plot with four replications; however, one replication was abandoned for late-season observations because of lack of efficacy of the insecticide treatment. The main plots were insecticide-protected versus unprotected, and the subplots were the 15 corn hybrids. The protected blocks were sprayed on 4 August with Capture™ at 0.08 lb AI/acre. Most of the hybrids had relative maturity ratings between 110 and 118 days. An attempt was made to pair each Bt hybrid with either a non-Bt sister line or another related non-Bt hybrid. The Pioneer hybrid did not have a sister hybrid, so in the discussion, it will be compared with Pioneer 3162, a leading hybrid in western Kansas. Other hybrids included were: Mycogen 7250, with reported native resistance to first generation European corn borer (ECB), and Pioneer 3751, a short-season standard check (97 days).

All corn borer infestations were natural. First-generation shot-hole damage was light, so plants in the two center rows showing noticeable damage were counted. Data for second generation corn borers were taken from five consecutive plants in one of the two center rows of each plot. The plants were dissected to measure corn borer tunneling and record the number and species of corn borer. Kernel damage (mostly corn earworm) was recorded as the estimated percentage of kernels damaged on each ear. In addition, lodged plants in the middle two rows were counted and separated into those girdled by southwestern corn borer (SWCB) and those lodged from other corn borer tunneling (mainly ECB damage). Yield was determined by hand harvesting the two middle rows of each plot in late October. Ears from standing plants and those from fallen plants were harvested separately. Grain yield for standing plants and total grain yield per acre at 15.5% moisture were calculated. To simplify the discussion, results of hybrids using the same Bt-event were averaged and compared with the average of the six comparison non-Bt hybrids (N7590, N7931, 4494, 2530, 7997, and 3162). For second-generation damage and yield information, the averages of the six non-Bt hybrids unsprayed and sprayed with Capture were compared, as well as the averages for the hybrids with the various Bt events.

[1]This research was supported by Kansas Corn Commission check-off funds through the Kansas Department of Agriculture.

Fig. 1. First-generation corn borer damage to whorl-stage corn expressed as the number of plants with damage out of about 90 in the two center rows of each plot, St. John, KS, 1997.

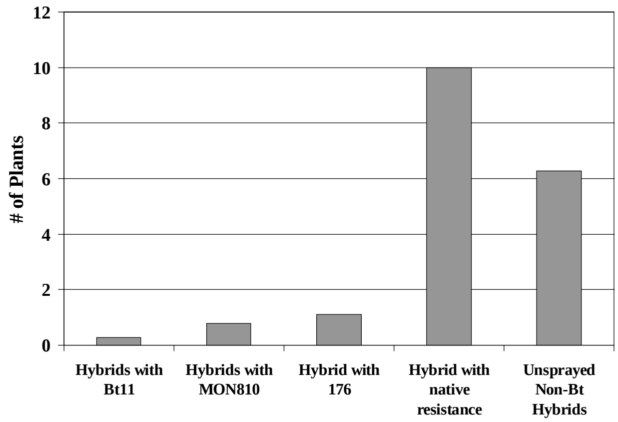
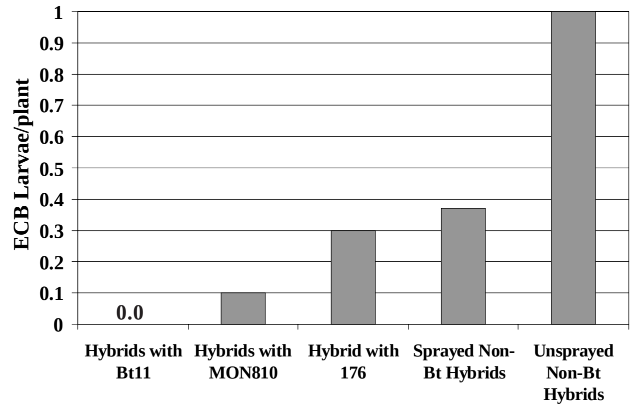


Fig. 2. Second-generation European corn borer larvae per plant, St. John, KS, 1997.



RESULTS AND DISCUSSION

Although first-generation corn borer damage was very light, all of the Bt hybrids were found to be very effective at controlling it (Table 1, Fig. 1). Hybrids with Bt11, MON810, and 176 averaged 95, 87, and 83% reductions in the number of plants infested per plot, respectively, when compared with the average of the six non-Bt hybrids. The native resistance in Mycogen 7250 provided no reduction in the number of plants showing damage when compared to the non-Bt hybrids. Second generation ECB and SWCB pressures averaged 1.0 and 0.7 larvae per plant, respectively, in the unsprayed non-Bt plots (Tables 1 & 2). Bt11, MON810, 176 and the insecticide treatment respectively reduced second-generation ECB larvae by 100, 93, 69, and 62% (Fig. 2); second-generation SWCB larvae by 100, 97, 22, and 66% (Fig. 3); girdled plants by 96, 90, 78, and 58% (Fig. 4); corn borer tunneling by 100, 93, 51, and 68% (Fig.5); and reduced yield losses from lodged plants by 96, 82, 33, and 58% (Fig 6). Events Bt11 and MON810 appeared to be significantly better at reducing second-generation SWCB larvae than did event 176. The five "YieldGuard" hybrids, with Bt 11 or MON810, gave 96% and 98% controls of ECB and SWCB, respectively, compared to 62% and 66% controls, respectively, for the best available insecticide treatment and 69% and 22% controls, respectively, for the Bt 176 hybrid.

Fig. 3. Second-generation southwestern corn borer larvae per plant, St. John, KS, 1997.

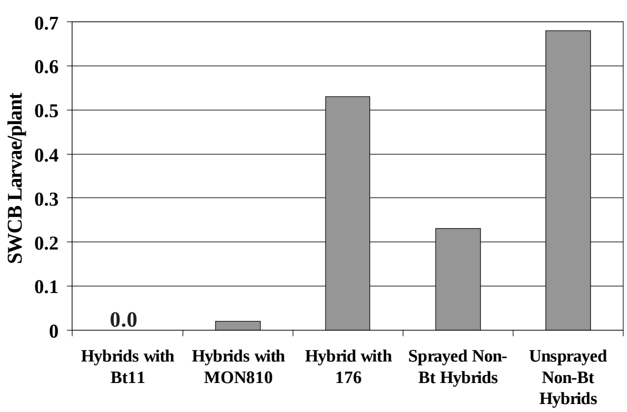


Fig. 4. Second-generation southwestern corn borer girdling damage expressed as the number of plants girdled out of about 90 in the two center rows of each plot, St. John, KS, 1997.

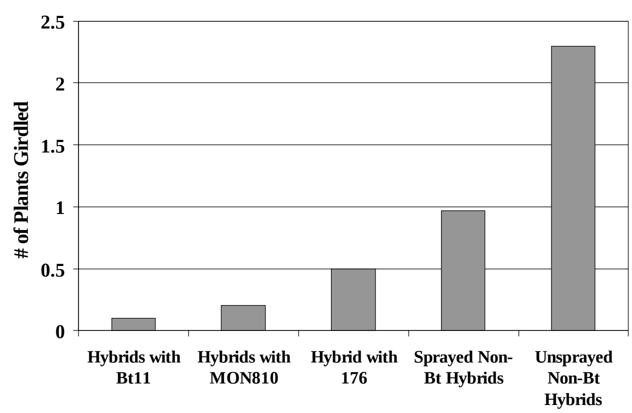


Fig. 5. Second-generation corn borer tunneling damage expressed as centimeters of tunneling per plant, St. John, KS, 1997.

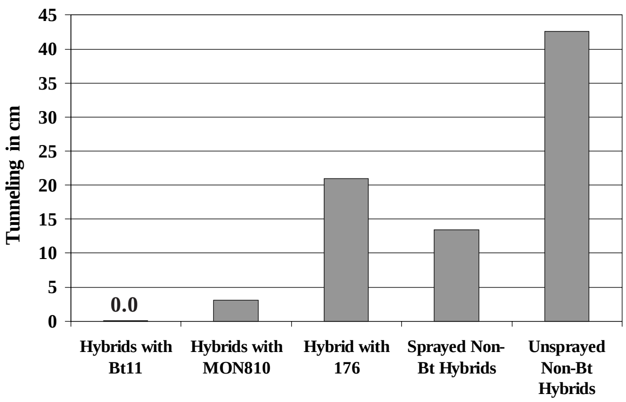
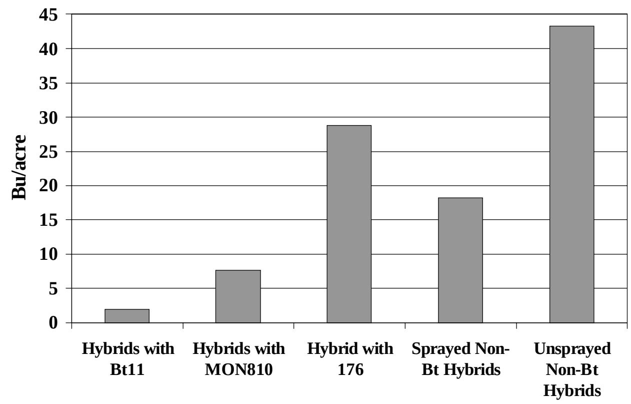


Fig. 6. Grain yield lost in plants lodged by corn borer girdling or tunneling damage, St. John, KS, 1997.



The five YieldGard hybrids in this trial showed very good yield potential with an average standing yield of 202.3 bu/acre in the unsprayed plots (Fig 7). This was an average of 26.4 bu/acre more than the yields of four comparison lines in the sprayed plots. The best unsprayed Bt hybrid (Novartis N7590BT) had a standing yield of 209.1 bu/acre which was 17.3 bu/acre better than the yield of the best sprayed non-Bt hybrid (Pioneer 3162).

Fig. 7. Grain yield for standing plants or plants lodged by corn borer girdling or tunneling damage, St. John, KS, 1997.

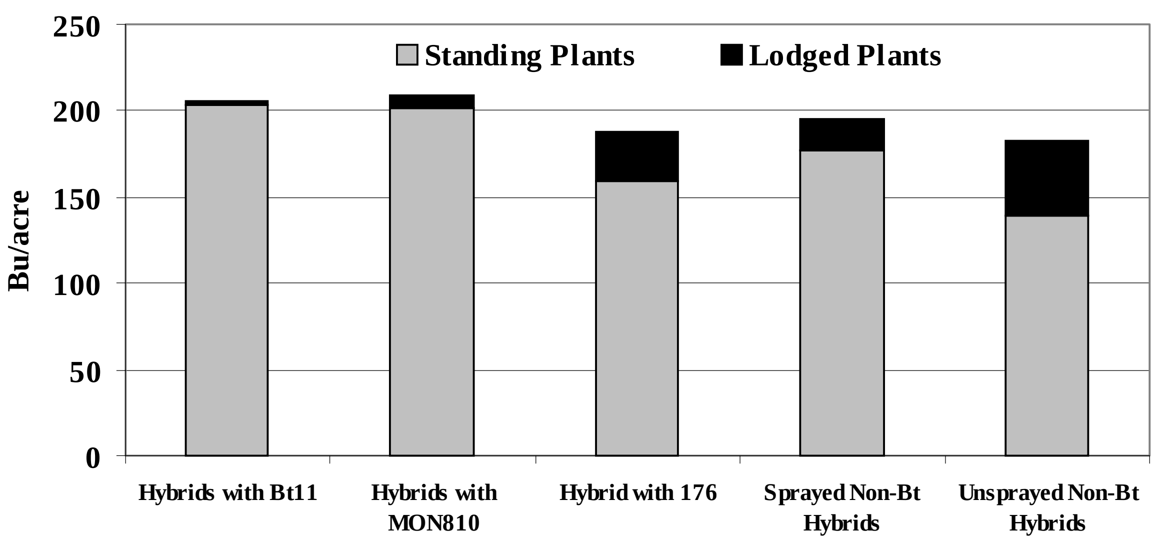


Table 1. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids, unsprayed block at St John, KS, 1997.

				Second Gen. Corn Borer				Grain Yield		
Hybrid	Bt Status	Company	First Gen # of plants with damage	ECB larvae per plant	SWCB larvae per plant	SWCB girdled plants/plot	Cm of tunneling per plant	Standing plts. bu/a	Fallen plts. bu/a	Total bu/a
N7590BT	Bt11	Novartis Seeds	0.3 e	0.0 e	0.00 d	0.1 e	0.0 e	209.1 a	3.8 c	212.8 ab
N7590	—	Novartis Seeds	5.0 d	0.7 bcde	0.93 a	2.7 abc	37.5 b	128.6 c	49.9 a	178.4 def
N7639BT	Bt11	Novartis Seeds	0.3 e	0.0 e	0.00 d	0.1 e	0.1 e	198.3 a	0.0 c	198.3 abcde
N7931	—	Novartis Seeds	5.9 cd	1.1 abc	0.93 a	2.5 abcd	47.1 ab	149.6 bc	44.6 a	194.1 abcdef
Max454	176	Novartis Seeds	1.1 e	0.3 cde	0.53 bc	0.5 e	21.0 cd	159.0 b	28.8 ab	187.7 cdef
4494	—	Novartis Seeds	5.6 cd	1.4 ab	0.53 bc	2.3 abcd	41.5 ab	139.5 bc	34.7 a	174.2 ef
7250[1]	—	Mycogen	10.0 a	1.0 abcd	0.73 ab	1.9 cd	42.1 ab	129.2 c	42.1 a	171.3 f
2530	—	Golden Harvest	8.7 ab	0.4 cde	0.47 bc	1.6 d	35.5 bc	144.7 bc	47.3 a	192.0 bcdef
2530BT	MON810	Golden Harvest	0.5 e	0.0 e	0.00 d	0.2 e	0.0 e	204.0 a	3.9 c	207.8 abc
8021BT	MON810	Cargill	1.3 e	0.0 e	0.00 d	0.4 e	1.5 e	194.4 a	8.2 c	202.6 abcd
7997	—	Cargill	4.6 d	0.5 cde	0.67 abc	3.0 ab	43.0 ab	132.7 c	48.9 a	181.6 def
33A14	MON810	Pioneer	0.7 e	0.2 de	0.07 d	0.1 e	7.7 de	205.8 a	11.1 bc	216.9 a
3162	—	Pioneer	8.1 abc	1.7 a	0.53 bc	1.6 d	50.7 ab	139.9 bc	33.6 a	173.4 f
3299	—	Pioneer	6.3 bcd	1.5 ab	0.33 cd	2.1 bcd	46.3 ab	140.6 bc	34.9 a	175.4 ef
3751	—	Pioneer	7.0 bcd	1.3 ab	0.67 abc	3.3 a	58.0 a	105.3 d	38.1 a	143.4 g
	LSD value p=0.05		2.41	0.72	0.33	0.93	15.40	21.53	19.54	21.42
	F-test Prob.		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]Hybrid reported to have native resistance to first generation European corn borer.
Means separated using DMRT, P=0.05.

Table 2. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids, sprayed block at St. John, KS, 1997.

				Second Gen. Corn Borer				Grain Yield		
Hybrid	Bt Status	Company	First Gen. # of plants with damage	ECB larvae per plant	SWCB larvae per plant	SWCB girdled plants/plot	Cm of tunneling per plant	Standing plts. bu/a	Fallen plts. bu/a	Total bu/a
N7590BT	Bt11	Novartis Seeds	—	0.0	0.0	0.0	0.0	214.6 ab	3.3	217.8 ab
N7590	—	Novartis Seeds	—	0.7	0.3	2.0	24.6	166.5 bcd	27.3	193.8 bcd
N7639BT	Bt11	Novartis Seeds	—	0.1	0.0	0.0	0.1	198.3 abc	1.4	199.7 abcd
N7931	—	Novartis Seeds	—	0.7	0.2	0.7	14.2	183.2 abcd	13.6	196.8 bcd
Max454	176	Novartis Seeds	—	0.4	0.3	0.6	16.0	166.6 bcd	23.2	189.9 cd
4494	—	Novartis Seeds	—	0.3	0.1	0.3	5.1	182.6 abcd	5.9	188.5 cd
7250[1]	—	Mycogen	—	1.3	0.4	2.3	30.4	158.0 cd	21.4	179.4 de
2530	—	Golden Harvest	—	0.3	0.2	1.2	9.8	173.7 abcd	17.4	191.0 bcd
2530BT	MON810	Golden Harvest	—	0.0	0.0	0.1	0.0	208.5 abc	5.2	213.6 abc
8021BT	MON810	Cargill	—	0.0	0.0	0.0	0.0	211.0 abc	2.1	213.1 abc
7997	—	Cargill	—	0.1	0.5	1.3	22.9	164.5 bcd	32.8	197.3 bcd
33A14	MON810	Pioneer	—	0.0	0.1	0.0	2.7	224.1 a	1.6	225.7 a
3162	—	Pioneer	—	0.1	0.1	0.3	4.1	191.8 abcd	12.0	203.8 abcd
3299	—	Pioneer	—	0.1	0.1	0.4	1.9	187.6 abcd	6.0	193.7 bcd
3751	—	Pioneer	—	0.4	0.3	1.7	19.4	141.5 d	19.9	161.4 e
LSD value p=0.05			—	0.88	0.44	2.11	28.59	45.58	25.87	23.8
F-test Prob.			—	0.1881	0.3833	0.3584	0.3918	0.0347	0.2542	0.0013

[1]Hybrid reported to have native resistance to first generation European corn borer.

Means separated using DMRT, P=0.05.

CORN BORER RESISTANCE AND GRAIN YIELD OF BT AND NON-BT CORN HYBRIDS AT GARDEN CITY, KS, 1997[1]

by
Larry Buschman, Phil Sloderbeck, Yu-Jie Guo, Randy Higgins[2], and MerleWitt

SUMMARY

Fifteen corn hybrids (six Bt- and nine non-Bt-corn) were evaluated for corn borer resistance and grain yield performance. All of the Bt hybrids were very effective at controlling first generation corn borer damage. Second-generation corn borer damage to posttassel corn was dependant on the Bt event. Hybrids with the Bt11 and MON810 events gave superior levels of control and appeared to have very good yield potential.

PROCEDURES

Corn hybrid plots were machine planted on 9 May at 30,000 seeds/acre at the Southwest Research-Extension Center near Garden City, KS. Spot replanting was done as necessary to fill in gaps in the plots, and hand thinning was done to adjust stands to a target of about 45 plants per row. The plots were four rows wide (10 ft) by 30 ft long with two rows (5 ft) of Bt corn planted between the plots as border rows and 10 ft alleyways at the end of each plot. The border rows and alleyways were included to reduce larval migration between plots. The experimental design was a split-plot with four replications. The main plots were insecticide-sprayed versus unsprayed, and the subplots were the 15 corn hybrids. The sprayed blocks were sprayed on 4 & 5 August with Capture™ at 0.08 lb AI/acre. Most of the hybrids had relative maturity ratings between 110 and 118 days. An attempt was made to pair each Bt hybrid with either a non-Bt sister line or another related non-Bt hybrid. The Pioneer hybrid did not have a sister hybrid, so in the discussion it will be compared with Pioneer 3162, a leading hybrid in western Kansas. Other hybrids included were Mycogen 7250, with reported native resistance to first-generation European corn borer (ECB), and Pioneer 3751, a short-season standard check (97 days).

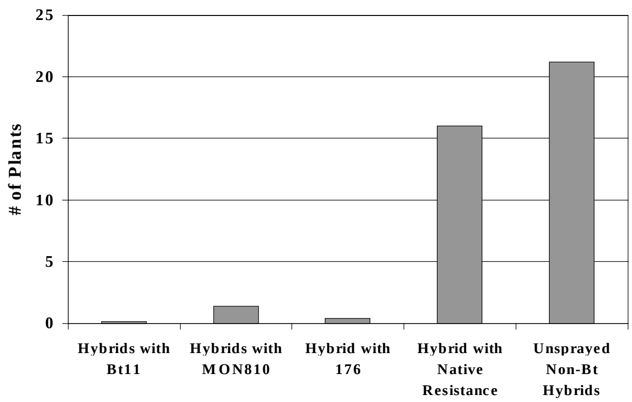
All corn borer infestations were natural. First-generation shot-hole damage was light, so plants showing noticeable damage in this two center rows were counted. Data for second-generation corn borers were taken from five consecutive plants in one of the two center rows of each plot. The plants were dissected to measure corn borer tunneling and record the number and species of corn borer. Kernel damage (mostly corn earworm) was recorded as the estimated percentage of kernels damaged on each ear. In addition, lodged plants in the middle two rows were counted and separated into those girdled by southwestern corn borer (SWCB) and those lodged from other corn borer tunneling (mainly ECB damage). Yield was determined by hand harvesting the two middle rows of each plot in late October. Ears from standing plants and those from fallen plants were harvested separately. Grain yield for standing plants and total grain yield per acre at 15.5% moisture were calculated. To simplify the discussion, results of hybrids using the same Bt-event were averaged and compared with the average of the six comparison non-Bt hybrids (N7590, N7931, 4494, 2530, 7997, and 3162). For second-generation damage and yield information, the averages of the six non-Bt hybrids unsprayed and sprayed with Capture were compared, as well as the averages for the hybrids with the various Bt events.

RESULTS AND DISCUSSION

Although first generation damage was very light, all of the Bt hybrids were found to be very effective at controlling it (Table 1, Fig. 1). Hybrids with Bt11, MON810, and 176 averaged 99, 94, and 98%

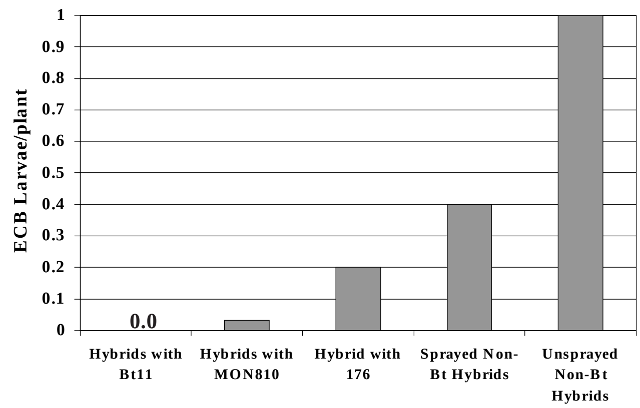
[1]This research was supported by Kansas Corn Commission check-off funds through the Kansas Department of Agriculture.
[2]Department of Entomology, Kansas State University, Manhattan.

Fig. 1. First-generation corn borer damage to whorl stage corn expressed as the numberof plants with damage out of about 90 in the two center rows of each plot. Garden City, KS, 1997.



reductions in the number of plants infested per plot, respectively, when compared with the average of the six non-Bt hybrids. The native resistance in Mycogen 7250 provided only a 25% reduction in the number of plants showing damage when compared to the same non-Bt hybrids. Second-generation ECB and SWCB pressures averaged 1.1 and 0.1 larvae per plant, respectively, in the unsprayed non-Bt plots (Tables 1 & 2). Bt11, MON810, 176 and the insecticide treatment respectively reduced second-generation ECB

Fig. 2. Second-generation European corn borer larvae per plant, Garden City, KS, 1997.



larvae by 100, 97, 80 and 64%, (Fig. 2); corn borer tunneling by 100, 90, 54, and 54% (Fig. 3); girdled plants by 100, 89, 42, and 69% (Fig. 4); ear tip damage by 67, 67, 26, and 18% (Fig. 5); and yield losses from lodged plants by 92, 85, 52, and 46% (Fig. 6). The five "YieldGard" hybrids, with Bt 11 and MON810, gave 98% and 93% controls for ECB and SWCB, respectively, compared to 64% and 54% controls, respectively, for the best available insecticide treatment and 80% and 54% controls, respectively,

Fig. 3. Second-generation corn borer tunneling damage expressed as centimeters of tunneling per plant, Garden City, KS, 1997.

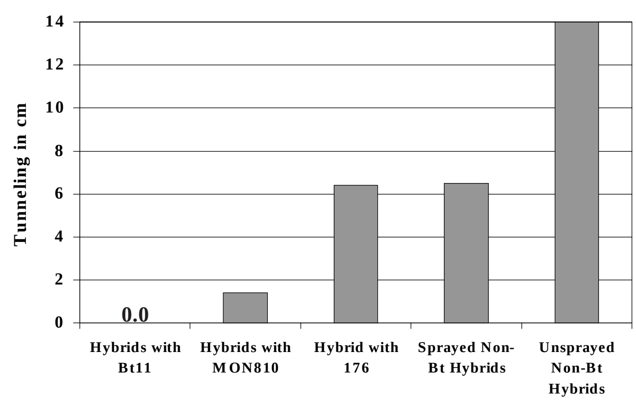


Fig. 4. Second-generation southwestern corn borer girdling damage expressed as number of plants girdled out of about 90 in the two center rows of each plot, Garden City, KS, 1997.

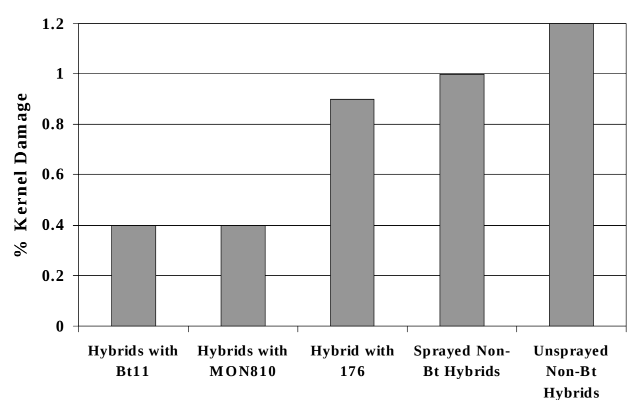


Fig. 5. Kernel damage in the ear, mostly due to corn ear worm feeding, expressed as percentage of ear damaged, Garden City, KS, 1997.

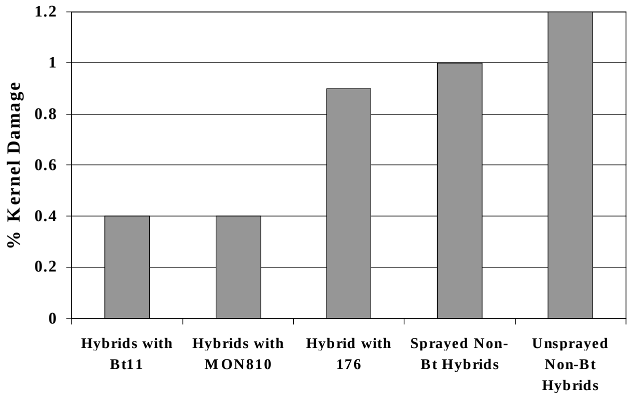
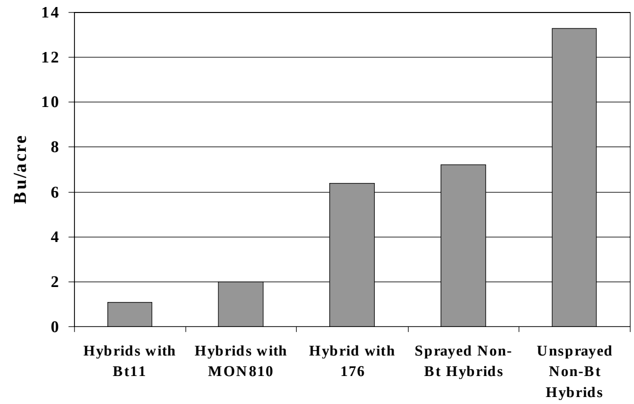


Fig. 6. Grain yield lost in plants lodged due to corn borer girdling or tunneling damage, Garden City, KS, 1997.



for the Bt 176 hybrid. The five YieldGard hybrids in this trial showed very good yield potential with an average standing yield of 213.3 bu/acre in the unsprayed plots (Fig 7). This was an average of 12.2 bu/acre more than the yields of the four comparison lines in the sprayed plots. The best unsprayed Bt hybrid (Pioneer 33A14) had a standing yield of 231.6 bu/acre, which was 18.5 bu/acre better than the yield of the best sprayed non-Bt hybrid (Cargill 7997).

Fig. 7. Grain yield for standing plants or plants lodged by corn borer girdling or tunneling damage, Garden City, KS, 1997.

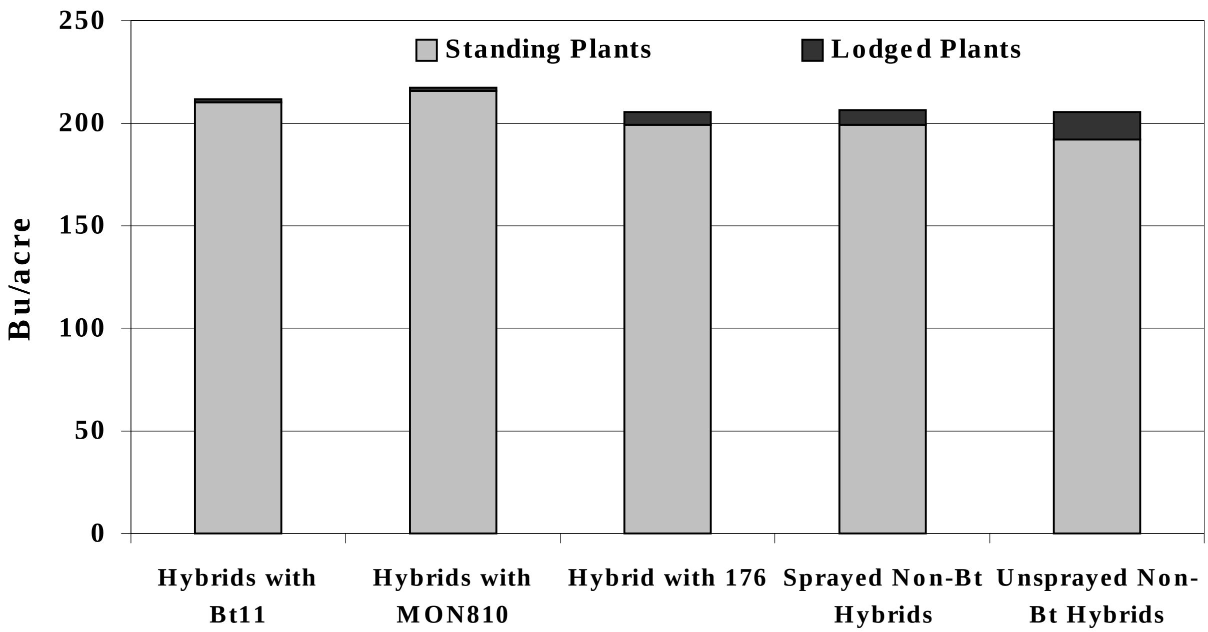


Table 1. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids, unsprayed block at Garden City, KS, 1997.

			First Gen.	Second Gen. Corn Borer				Grain Yield		
Hybrid	Bt Status	Company	# of plants with damage	ECB larvae per plant	SWCB larvae per plant	SWCB girdled plants/plot	Cm of tunneling per plant	Standing plts. bu/a	Fallen plts. bu/a	Total bu/a
N7590BT	Bt11	Novartis Seeds	0.0 f	0.0 d	0.00 d	0.0 d	0.5 bc	213.7 ab	2.2 cd	215.9 b
N7590	—	Novartis Seeds	14.4 de	0.5 bcd	0.40 bcd	6.7 cd	1.0 bc	196.8 bcd	13.3 bc	210.1 bc
N7639BT	Bt11	Novartis Seeds	0.3 f	0.0 d	0.00 d	0.0 d	0.3 bc	206.9 bc	0.0 d	206.9 bc
N7931	—	Novartis Seeds	11.5 e	1.7 a	1.50 a	21.9 ab	2.4 b	177.6 d	25.3 a	202.9 bc
Max454	176	Novartis Seeds	0.4 f	0.2 cd	0.35 bcd	6.4 cd	0.9 bc	199.0 bcd	6.4 bcd	205.4 bc
4494	—	Novartis Seeds	19.0 cd	1.1 abc	0.40 bcd	14.7 bc	1.1 bc	197.0 bcd	9.6 bcd	206.5 bc
7250[1]	—	Mycogen	16.0 cde	1.1 abc	0.30 bcd	14.7 bc	0.6 bc	195.3 bcd	8.7 bcd	204.0 bc
2530	—	Golden Harvest	30.1 b	0.5 bcd	0.15 cd	6.9 cd	0.8 bc	187.6 cd	9.4 bcd	197.0 c
2530BT	MON810	Golden Harvest	1.0 f	0.0 d	0.05 d	0.1 d	0.4 bc	209.0 bc	1.8 cd	210.8 bc
8021BT	MON810	Cargill	2.0 f	0.1 cd	0.00 d	1.5 d	0.3 c	205.5 bc	0.5 d	206.1 bc
7997	—	Cargill	14.4 de	0.9 abcd	0.60 bcd	14.9 bc	0.9 bc	198.1 bcd	12.2 bcd	210.3 bc
33A14	MON810	Pioneer	1.1 f	0.0 d	0.15 cd	2.7 d	0.5 bc	231.6 a	3.6 cd	235.3 a
3162	—	Pioneer	37.9 a	1.4 ab	0.55 bcd	18.7 ab	1.1 bc	195.7 bcd	10.2 bcd	205.9 bc
3299	—	Pioneer	20.0 c	1.3 ab	0.90 b	18.1 ab	1.3 bc	188.9 cd	17.1 ab	206.0 bc
3751	—	Pioneer	14.5 de	1.8 a	0.70 bc	26.3 a	7.9 a	141.9 e	18.1 ab	159.9 d
	LSD value p=0.05		5.05	0.90	0.54	9.79	1.73	18.97	10.31	13.91
	F-test Prob.		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]Hybrid reported to have native resistance to first generation European corn borer.

Means separated using DMRT, P=0.05.

Table 2. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids, sprayed block at Garden City, KS, 1997.

			First Gen.	Second Gen. Corn Borer				Grain Yield		
Hybrid	Bt Status	Company	# of plants with damage	ECB larvae per plant	SWCB girdled plts/plot	Cm of tunneling per plant	Ear tip damage % kernels	Standing plts. bu/a	Fallen plts. bu/a	Total bu/a
N7590BT	Bt11	Novartis Seeds	—	0.0 c	0.0	0.0 d	0.5	207.8 bc	5.7 bcd	213.5 bc
N7590	—	Novartis Seeds	—	0.3 bc	0.1	3.9 bcd	0.9	196.4 bc	11.3 ab	207.7 bcd
N7639BT	Bt11	Novartis Seeds	—	0.0 c	0.0	0.0 d	0.4	212.4 b	0.0 d	212.4 bc
N7931	—	Novartis Seeds	—	0.3 bc	0.5	6.2 abcd	0.3	199.9 bc	12.9 a	212.8 bc
Max454	176	Novartis Seeds	—	0.2 bc	0.3	3.1 cd	1.3	199.3 bc	1.9 cd	201.2 bcd
4494	—	Novartis Seeds	—	0.1 c	0.1	5.1 bcd	1.2	190.6 c	2.9 cd	193.5 d
7250[1]	—	Mycogen	—	0.5 abc	0.0	8.7 abc	0.9	197.9 bc	5.8 bcd	203.7 bcd
2530	—	Golden Harvest	—	0.2 bc	0.2	3.7 cd	0.5	190.5 c	6.8 bc	197.3 cd
2530BT	MON810	Golden Harvest	—	0.0 c	0.0	0.0 d	0.4	208.1 bc	1.2 cd	209.4 bcd
8021BT	MON810	Cargill	—	0.0 c	0.0	0.0 d	0.1	209.8 b	1.0 cd	210.8 bc
7997	—	Cargill	—	0.3 bc	0.1	8.0 abc	0.4	213.1 b	4.4 cd	217.5 b
33A14	MON810	Pioneer	—	0.0 c	0.0	0.3 d	0.4	235.4 a	2.3 cd	237.7 a
3162	—	Pioneer	—	1.0 a	0.1	11.8 a	2.7	205.6 bc	4.7 cd	210.3 bc
3299	—	Pioneer	—	0.9 a	0.1	10.4 ab	1.3	196.2 bc	7.2 abc	203.3 bcd
3751	—	Pioneer	—	0.7 ab	0.3	9.5 abc	2.7	146.4 d	5.6 bcd	152.1 e
		LSD value p=0.05	—	0.45	0.32	5.64	2.00	15.97	5.59	14.30
		F-test Prob.	—	0.0002	0.1207	<0.0001	0.2092	<0.0001	0.0008	<0.0001

[1]Hybrid reported to have native resistance to first generation European corn borer.

Means separated using DMRT, P=0.05.

PHYTOSYEIID AND OTHER PREDATORS ASSOCIATED WITH BANKS GRASS MITES IN CORN AND SURROUNDING NATIVE VEGETATION

by

Larry Buschman, Matthew Messenger,[1] and James Nechols[2]

SUMMARY

Commercially available predatory mites were released into the border vegetation around corn fields to determine if they could become established and enhance biological control of Banks grass mites in the corn. Sampling was done from May through July at about 2-week intervals. Corn and alternate host material were placed in large Berlese funnels to extract spider mites and predators into alcohol. None of the released phytosyeiid mites were recovered, and no significant differences occurred in the spider mite populations or predator mite populations in release and nonrelease fields. Five species of native predatory mites were identified.

INTRODUCTION

Biological control of spider mites in corn currently occurs through conservation of predators such as the phytosyeiids. This is done by delaying insecticide applications or using insecticides with less impact on the benificial species. Supplemental releases of phyosyeiids could provide a more predictable level of predator activity and allow them to build up and control spider mite populations. The objectives of this study were to release commercially available phytosyeiids early in the season and try to document enhanced numbers of phytosyeiids in the corn of release fields compared to nonrelease fields. We also report the presence of several native phytosyeiids and describe their seasonal occurrence.

PROCEDURES

Winter wheat and native grasses surrounding commercial corn fields in southwestern Kansas were surveyed in the spring and early summer 1996 and 1997. Corn fields with Banks grass mite (BGM) populations present in adjacent hosts then were paired up so that each pair of fields had similar hosts, mite populations, location, and irrigation. One field for each pair was randomly designated the release field. In 1996, eight corn fields (four pairs) were chosen (two sites in Finney Co., two sites in Haskell Co., and four sites in Kearny Co.). In 1997, 12 fields (six pairs) were chosen (six sites in Haskell Co., six sites in Kearny Co.). Winter wheat was the adjacent host surrounding all fields in Finney Co. and Haskell Co. Downy brome, volunteer wheat, and other native grasses were the adjacent hosts for all sites in Kearny Co. The corn hybrid was Pioneer 3162 in all fields. All fields were subject to standard pesticide applications, including miticide and insecticide treatments. Alternate hosts also were sampled during the winter of 1996-97 around selected fields.

In 1996, a mixture of three phytosyeiids, *Neoseiulus fallacis* (Garman), *N. californicus* (McGregor), and *Galandromus occidentalis* Nesbitt, was released around the perimeter of the release fields on the alternate hosts. In 1997, only *N. californicus* was released. Release dates were May 30 and June 12, 1996 and June 18, 1997.

Alternate hosts and corn was sampled every 2 weeks. In winter wheat, three to four samples of 3 row-feet of vegetation were taken. Two to three samples of 1 square foot of native vegetation were taken. In corn, samples consisted of two plants selected at random in each of five sample sites set up along a transect into the field. The samples were placed in 20-gallon Berlese funnels for 3 days with a light bulb for heat. Arthropods were collected in 70% methanol and suctioned onto 9-cm #10 black-ruled filter paper using a Buchner funnel. The filter paper was examined under a binocular microscope to record spider mites, phytosyeiids, thrips, minute pirate bugs, and other

[1]Former Graduate Research Assistant, Department of Entomology, Kansas State University, Manhattan.
[2]Department of Entomology, Kansas State University, Manhattan.

predacious arthropods. These numbers were converted to numbers per square meter for analysis and presentation.

The total numbers of spider mites, phytosyeiids, and other arthropods calculated across fields by sample block were analyzed for differences between release versus nonrelease fields. Simple linear correlation analysis was performed on the number of phytosyeiids, thrips, and *Orius* spp. versus several potential prey species, such as spider mites or thrips, in corn or alternate hosts.

RESULTS AND DISCUSSION

The nonnative phytosyeiids, *G. occidentalis* and *N. californicus*, released in 1996 and 1997 were not recovered, either in corn or in alternate host samples. *N. fallacis* was recovered in both years, but it was not possible to distinguish the released commercial strain from the naturally occurring population. No significant differences (P > 0.05) occurred between release and nonrelease fields, either in the number of spider mites or phytosyeiids recovered. Failure to recover any *N. californicus* in these studies was surprising, because previous studies in west Texas corn had been successful.

The BGM was the predominant spider mite recovered in corn in both years. The twospotted spider mite was recovered only once in 1997. In spring 1996, BGM populations exceeded 1000 per sq m around four fields and exceeded 100 per sq m around all eight fields. Large numbers of BGM dispersed into the corn, and populations seemed to peak during mid-July, for example Kearny Co #3 (Fig. 1). BGM populations exceeded 1000 per sq m in four fields and exceeded 100 per sq m in seven fields. A general decline in BGM populations occurred during the first week of August, and only one miticide was applied on the eight fields.

In spring 1997, BGM populations did not exceed 100 per sq m in any of the 12 fields. In corn, BGM populations were very low throughout spring and early summer, for example Kearny Co. #4 (Fig. 3). BGM populations exceeded 100 per sq m in only four of the 12 fields. However, the weather turned hot and dry in late July, and BGM populations were beginning to increase in some fields, so seven of the 12 fields were treated with a miticide. Surprisingly, adverse effects of the miticide applications on BGM populations were not obvious in the biweekly samples (Fig. 3). A natural BGM population decline was associated with a rainy period in early August, but the second half of August was dry, and mite populations began to increase again in some fields (Fig. 3).

Fig. 1. Population trends of BGM and N. fallacis in corn and alternate hosts for Kearny #3 - 1996. This was a phytoseiid release field. Arrows indicate application of encapsulated methyl parathion at 0.28 kg (AI)/ha (19 July) and dimethoate at 0.56 kg (AI)/ha (3 August).

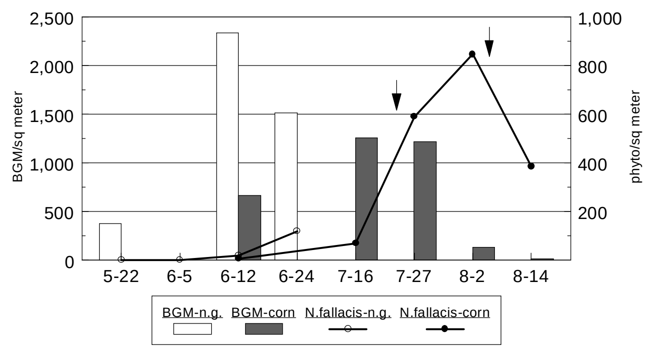
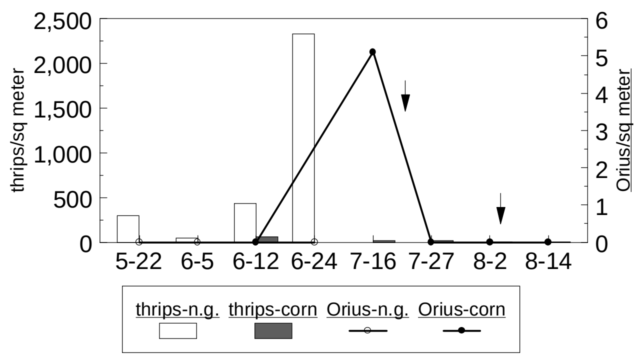


Fig. 2. Population trends of thrips and Orius sp. in corn and alternate hosts for Kearny #3 - 1996.



The phytosyeiids were the most abundant spider mite predators in both years. Five species were recovered in corn, wheat, and native grasses. In order of abundance they were: *Neoseiulus fallacis*, *N. comitatus* (DeLeon), *N. setulus* (Fox), *Proprioseiopsis ovatus* (Garman), and *Amblyseiella setosa* Muma. Of the recovered phytosyeiids, 66% were *N. fallacis* and 29% were *N. comitatus*. All five phytosyiid species were recovered in alternate host vegetation sampled during the overwintering period.

N. fallacis was the most abundant of all the predators. In corn, it accounted for 90 to 99% of the phytosyeiids recovered (Fig. 5). In the alternate hosts, it was not so predominant, but it still accounted for 7 to 26% of the phytosyeiids recovered (Fig. 6). In addition, *N. fallacis* populations correlated significantly (P = 0.05) with spider mite populations (a potential prey) in corn in both years and also in the alternate hosts in 1996. *N. fallacis* populations were much higher in 1996 than in 1997. At most sites, the

Fig. 3. Population trends of BGM and N. fallacis in corn and alternate hosts for Kearny #4 - 1996. This was a control field (no phytosyeiid release). Arrows indicate application of chlorpyrifos at 1.12 kg (AI)/ha (27 June) and bifenthrin at 0.053 kg (AI)/ha (4 August).

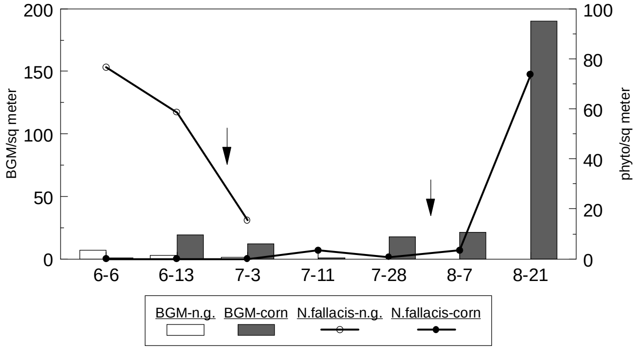


Fig. 4. Population trends of thrips and Orius sp. in corn and alternate hosts for Kearny #4 - 1996.

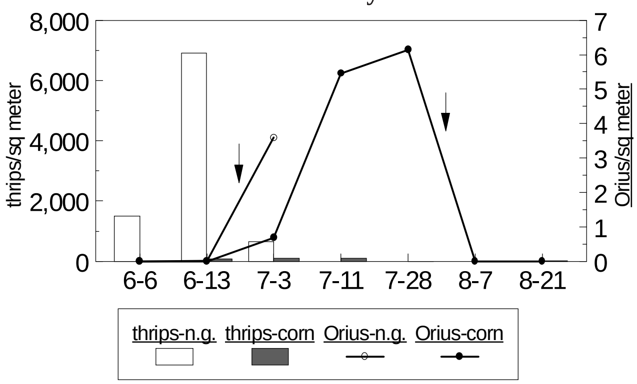
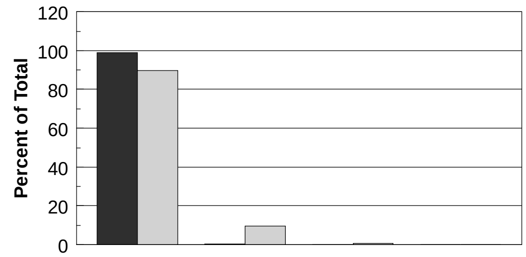
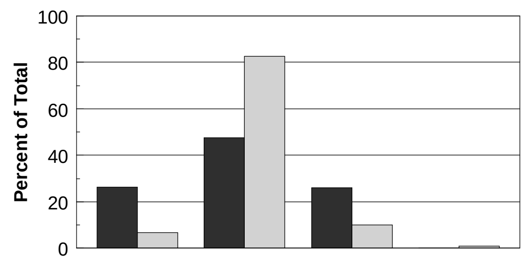


Fig. 5. Percentage of each species of phytosyeiid recovered from corn, southwestern Kansas.



Phytosyeiid Species	N. fallacis	N. comitatus	N. setulus	P. ovatus
1996	99.1	0.5	0.2	0.2
1997	89.7	9.6	0.6	0.1

Fig. 6. Percentage of each species of phytosyeiid recovered from alternate hosts such as wheat, downy brome and native grasses, southwestern Kansas.



Phytosyeiid Species	N. fallacis	N. comitatus	N. setulus	P. ovatus
1996	26.2	47.5	26.1	0.2
1997	6.6	82.5	9.9	1.0

populations in the alternate hosts peaked in mid-June and in corn during the first part of August (Figs. 1 & 3). Up to 1055 *N. fallacis* were recovered in a single sample of two corn plants. Surprisingly, the populations did not seem to be affected adversely by the pesticide applications (Fig. 3), except for Kearny Co #3 (Fig. 1).

N. comitatus was the most abundant phytosyeiid recovered in wheat and native grass samples, accounting for 48 to 83% of the total (Fig. 6). It was also the most common phytosyeiid recovered in small corn (8- to 11-leaf stage) from May until mid-June, but it did not seem to survive well on corn and soon disappeared. This was the second most abundant phytosyeiid in corn, but it accounted for only 0.5 to 10% of the total (Fig. 5). Populations seemed to peak in the alternate hosts by late June and were much higher in 1997 than in 1996. *N. comitatus* populations did not correlate with populations of any potential prey tested. Up to 514 *N. comitatus* were recovered in a 3-row foot sample of winter wheat.

Orius insidiosus (Say) (Hemiptera: Anthocoridae) was the second most abundant predator in corn and in alternate host plants. *Orius* populations were present in each corn field and on most alternate hosts. They seemed to peak in the last week of June on the alternate hosts and in July on corn (Figs. 2 & 4). They seemed to decline as corn reached the tassel stage. *Orius* populations were significantly correlated (P = 0.05) with thrips populations (the potential prey) on corn (1997) and in alternate hosts (1996). Up to 23 adults and 62 nymphs were recovered from a 3 row-foot sample of winter wheat. *Orius* populations appeared to be affected adversely by the pesticide applications (Figs. 1 & 2). They declined following 17 of 26 pesticide applications; however, most of these applications were made after tassel stage when populations were declining naturally.

The fungal pathogen, Neozygites adjarica (Tsintsadze & Vartapetov) (Entomophthorales: Neozygitaceae), was recorded from infected spider mites in August 1996 when epizootics occurred in two fields.

IMPACT OF PALMER PIGWEED ON QUALITY AND YIELD OF WHOLE-PLANT CORN

by
Randall Currie, Kelly Kreikemeier, and Rafael Massinga[1]

SUMMARY

Economic losses were seen with as few as one Palmer pigweed per 2 meters of row, whether corn was harvested as grain or forage. However, at this lowest level of infestation, when pigweed and corn were harvested collectively for forage instead of grain alone, economic losses were reduced more than 8% in both years of this test. This advantage was magnified greatly in corn containing eight Palmer pigweeds per meter of row. Economic loss was reduced more than 34% in both years. Although in vitro dry matter digestibility was reduced from 81.6% to 72% at the highest level of pigweed infestation, whole plant DM yield per acre was reduced greater than 34%. Because corn forage with the highest level of pigweed infestation was still good quality, economic losses can be reduced by harvesting crop and weed together for silage.

INTRODUCTION

Palmer pigweed has supplanted redroot pigweed as the chief pigweed species in corn in southwestern Kansas. Even under good management, a producer often is confronted with a level of Palmer pigweed that causes an economic loss. Therefore, the objective of this experiment was to determine if these losses could be reduced by cutting weed-infested corn for silage.

PROCEDURES

Corn was planted in 30-inch rows at 36,000 plants/acre and fertilized and flood irrigated for maximum production. Palmer pigweed was thinned to one, two, four, or eight plants/meter of corn row. All other weeds were removed throughout the season by weekly hoeing. Corn grain was harvested from two rows of each plot, and another two rows were harvested for forage. In vitro dry matter digestibility (IVDMD), which simulates ruminal fermentation, was measured on all forage samples.

RESULTS AND DISCUSSION

At 0.5 Palmer pigweed/meter of row emerging with the corn, forage yield losses were14.6 and 14.2%, and grain yield losses were 24.9 and 22.5%S in 1996 and 1997, respectively. As populations of pigweed increased, the difference between forage and grain losses increased (Fig. 1). In plots with eight Palmer pigweed/meter of row, forage yield losses were 57.1 and 34.1% and grain losses were 91.8 and 74.0% in 1996 and 1997, respectively. Although total forage yield and quality declined with increasing Palmer pigweed population, declines in IVDMD were minor compared to declines in forage yield. The IVDMD decreased from 81.6% in weed-free plots to 72.0% at eight Palmer pigweed/meter of row (Fig. 2). Therefore, weed-free forage had very high feeding value. However, even corn forage with the highest infestation of pigweed appeared to be good quality. Therefore, we conclude that economic losses increase at all levels of Palmer pigweed regardless of harvest method, but economic losses can be reduced by harvesting the corn and Palmer pigweed collectively as forage rather than harvesting the corn for grain alone.

---

[1]Graduate Student, Kansas State University, Manhattan.

Fig. 1. Corn forage and grain losses in 1996 and 1997, Garden City, KS.

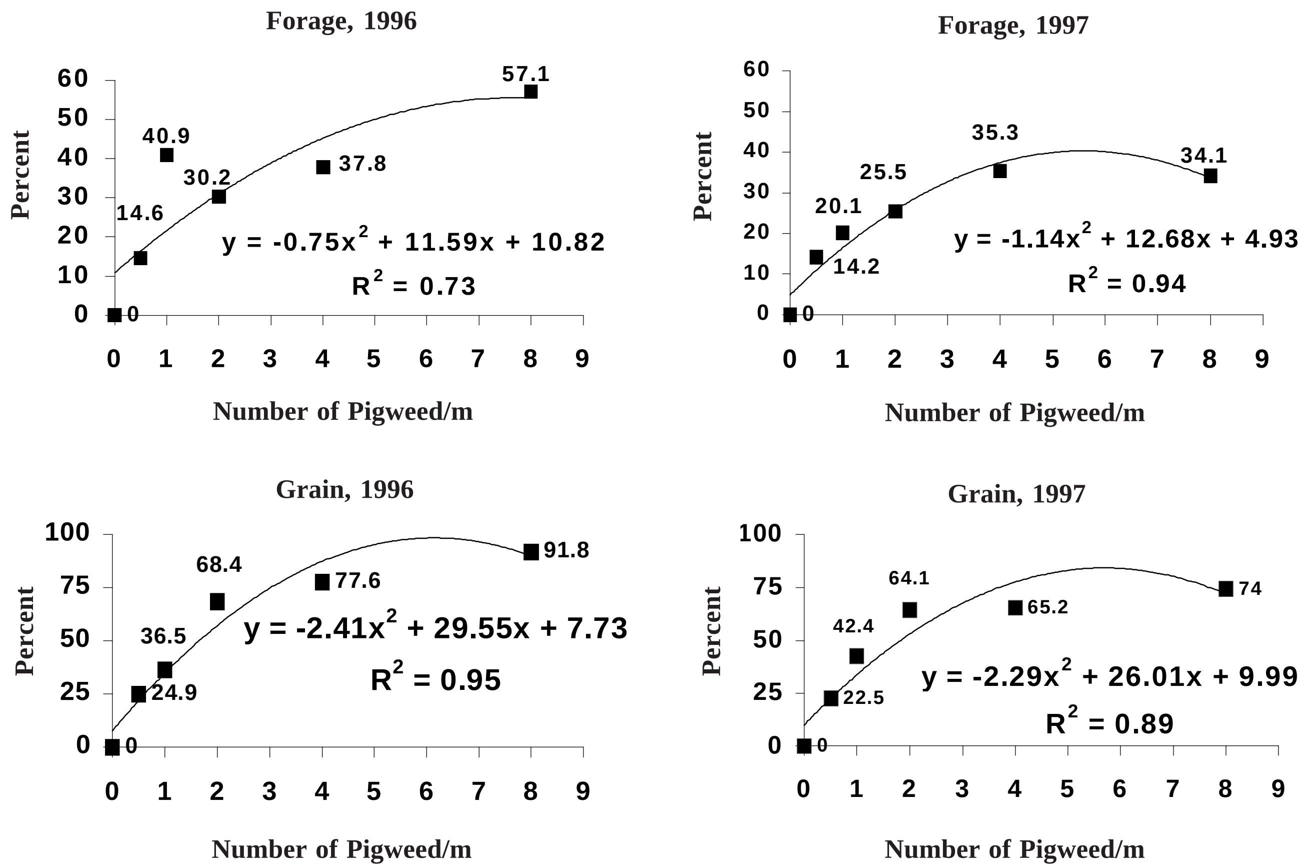
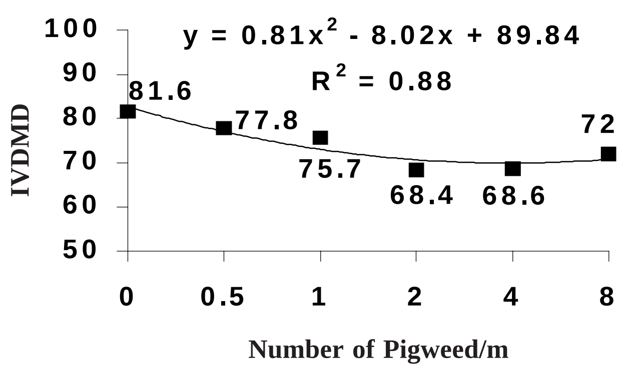


Fig. 2. Effect of Palmer pigweed populations on corn digestibility (IVDMD) in 1997, Garden City, KS.



GROWTH OF PALMER PIGWEED IN CORN AND IN MONOCULTURE

by
Randall Currie, Rafael Massinga, and Michael Horak[1]

SUMMARY

Field studies were conducted in 1996 and 1997 at Garden City, Kansas to evaluate the influence of density and time of emergence on growth of Palmer pigweed in monoculture and in competition with corn. Palmer pigweed was planted concurrently with corn in both years, at corn 6-leaf stage in 1996, and at corn 3-leaf stage in 1997. Overall, Palmer pigweed seed production and dry weight declined as density increased. The effect of emergence date on dry weight was more critical when Palmer pigweed was competing with corn than when it was grown alone. Seed production was higher in pigweed growing by itself than in competition with corn, but seed production under competition was still high when it emerged at corn 4-leaf stage. Palmer pigweed emergence at corn 7-leaf stage reduced seed production to under 10% of the amount produced in monoculture. The results emphasize the importance of controlling this weed early in the season not only to reduce its competitive effects on corn but also to reduce the amount of seed that will emerge in later years.

INTRODUCTION

Palmer pigweed is a common species in the southern Great Plains. It is a dioceous species that can grow 9-12 ft tall and produce more than 600,000 seeds/plant. In the past few years, Palmer pigweed has increased in severity in Kansas and throughout the region. Information about competitive effects of corn on Palmer pigweed will help the development of an integrated management program for this weed.

Therefore, the objective of the study was to evaluate the effect of time of emergence and additive densities on seed production and dry weight of Palmer pigweed growing in competition with corn and in monoculture.

PROCEDURES

The study was conducted at the Southwest Research-Extension Center, Garden City, KS, in 1996 and 1997. Palmer pigweed was seeded in corn and by itself at densities of 0.5, 1, 2, 4, and 8 plants/meter of row on two different dates (Table 1) each year. Palmer pigweed was harvested at corn maturity and oven dried (70 C). Seed production and dry weight/plant were determined.

Table 1. Palmer pigweed planting and emergence dates.

Planting Date	Emergence Date	Corn Leaf Stage
	1996	
May 21	June 3	—
June 17	June 22	7
	1997	
May 22	May 28	4
June 5	June 10	—

RESULTS AND DISCUSSION

The number of seed produced/plant of Palmer pigweed both in corn and growing by itself decreased as density increased. For example, in 1996 when planted in May, Palmer pigweed grown by itself produced about 900,000 seeds/plant at 0.5 plant/meter and 200,000 at a density of 8 plants/meter. In competition with corn, seed number per plant decreased from 400,000 to 43,000 at the same densities. The same trend was observed in 1997, but the number of seed produced per plant was lower than in 1996. Seed production was higher when Palmer pigweed was grown by itself than in competition with

[1]Department of Agronomy, Kansas State University, Manhattan.

corn and when planted in May than in June.

Palmer pigweed can emerge very rapidly (within 5 to 11 days), resulting in early competition for corn.

Palmer pigweed density and emergence date influenced the final dry weight and seed production both in monoculture and in competition with corn. As density increased, dry weight and seed production decreased.

The effect of emergence date was more critical for Palmer pigweed growing in competition with corn than in monoculture. When it emerged early relative to corn (4-leaf stage), Palmer pigweed produced a large number of seeds. However, when it emerged later (corn 7-leaf), the number of seeds produced was very low (less than 10% of the number produced in monoculture).

These results confirm the need for early-season control of Palmer pigweed in corn not only to reduce the competitive effect on corn but also to reduce the number of seeds that will be added to the seed bank.

Fig. 1. Effect of pigweed density on seed production when grown with and without corn, Garden City, KS.

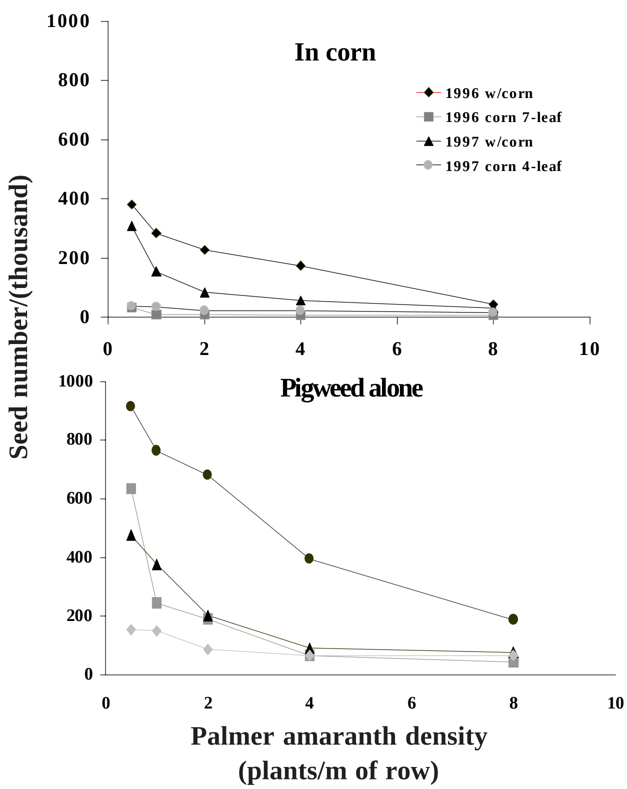
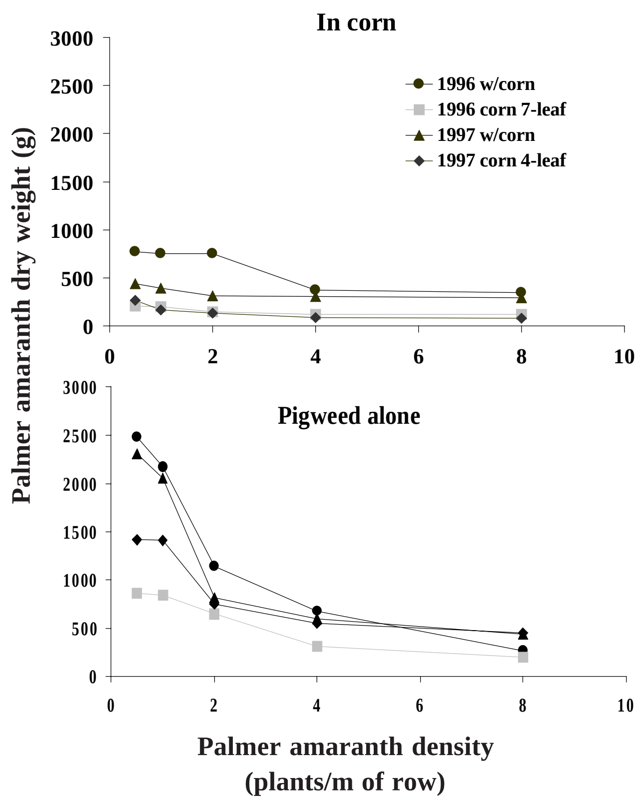


Fig. 2. Effect of pigweed density on dry weight when grown with and without corn, Garden City, KS.



COMPARISONS OF 12 TANK MIXES FOR WEED CONTROL IN SORGHUM

by
Randall Currie and Curtis Thompson

SUMMARY

Tank mixes containing more than 1 lb atrazine/acre were among the top-yielding treatments. Exceptions to this were seen when more expensive compounds were substituted for atrazine or lower rates of atrazine plus these higher priced compounds were used.

INTRODUCTION

Palmer pigweed has supplanted redroot pigweed in most of southwestern Kansas within the last several years. Because of the potential of pigweed species to develop resistance to atrazine and the perceived environmental threat of atrazine, much effort has been directed at finding replacements for it. Therefore, the objective of this study at Garden City was to compare Palmer pigweed control with various rates of atrazine in tank mixes and their proposed substitutes.

PROCEDURES

In an area with a noticeably high weed density, weeds were planted as described in Table 1. Sorghum was planted as described in Table 2. Herbicides were applied as described in Table 3. Weed number/sq ft was counted. Yield was determined by combine harvest and adjusted to 15.5% moisture.

Table 1. Weed seedling information.

Weeds:	Yellow foxtail, redroot pigweed, and crabgrass
Planting date:	5-28-97
Planting method:	14-ft. Great Plains drill
Carrier:	Cracked corn-40 lbs/acre
Rate:	Redroot pigweed-10 seeds/ft^2 Crabgrass-75 seeds/ft^2
Depth:	Broadcast on surface
Row spacing:	9 inches

Table 2. Crop information for sorghum.

Variety:	AGRIPRO 3195
Planting date:	6-18-97
Planting method:	JD Max Emerge, 6-row planter
Rate:	40,000 seeds/acre
Depth:	1.5 inches
Row spacing:	30 inches
Soil temp.:	80 F
Soil moisture:	Dry on top ½”, moist below
Emergence date:	6-24-97

RESULTS AND DISCUSSION

Early preplant applied herbicides provided excellent weed control prior to planting sorghum (data not shown). This could have been an advantage if a large acreage had been planted. Excellent seed bed conditions and timely rain after planting masked any advantage. Had tillage been necessary to produce a seed bed without early preplant applications or timely rains had not fallen, soil moisture for planting would have been lacking. This further delay in emergence could have hurt yield if an early fall frost had occurred.

Treatments followed by the letter T produced top yields, and they did not differ from one another statistically (Table 4). With the exception of treatments 1, 3, 8, and 11, all these top-yielding treatments contained more than 1 lb of atrazine.

Crabgrass stands were variable across the plot area; therefore we could not determine statistical differences between treatments. This was further exacerbated by a complex interaction with pigweed control. However, good crabgrass control generally appeared to be correlated with higher yields.

Pigweed was the dominant weed species in this test. Treatments followed by the letter T produced pigweed control not statistically different from 100%. Most treatments gave excellent pigweed control but not 1, 3, 4, and 9. Three of these treatments did not

Table 3. Application information, weed control in sorghum, Garden City, KS.

Date:	5-28-97	6-17-97	6-18-97	7-8-97	7-11-97
Method:	Broadcast	Broadcast	Broadcast	Broadcast	Broadcast
Timing:	PrePlant	PrePlant	Pre	Post	Post
Air temp.:	90 F	82 F	92 F	95 F	75 F
% relative humidity:	40%	60%	45%	41%	80%
Dew presence:	No	No	No	No	No
Soil temp.:	70 F	80 F	82 F	90 F	75 F
Appl. Equipment:	Windshield sprayer boom	Tractor sprayer	Windshield sprayer	Windshield sprayer	Windshield sprayer
Boom length:	10 ft	30 ft	10 ft	10 ft	10 ft
Pressure, psi:	35	33	35	35	35
Nozzle type:	Teejet XR	Teejet XR	Teejet XR	Teejet XR	Teejet XR
Nozzle size:	8004VS	80015VS	8004VS	8004VS	8004VS
Nozzle spacing:	20 in.	20 in.	20 in.	20 in.	20 in.
Boom height:	18 in.	18 in.	18 in.	18 in.	18 in.
Ground speed:	3.3 mph	3.0 mph	3.3 mph	3.3 mph	3.3 mph
Appl. rate:	20 gpa	20 gpa	20 gpa	20 gpa	20 gpa

Table 4. Harvest data, weed control in sorghum, Garden City, KS.

	Treatment	Rate (lb. AI/A)	Appl. Timing	Yield* bu/A	Pigweed #/sq ft	Crabgrass #/sq ft
1	Peak+COC	0.12, 1.25%	Post	34.7	1.0	4.0
2	Peak+Atrazine+COC	0.054, 0.8, 1.25%	Post	24.5	0.0	9.3
3	Peak+Banvel+NIS	0.054, 0.125, 0.25%	Post	35.2	1.0	9.0
4	Optil+Poast+Atrazine+COC	1.5, 0.19, 1.5, 0.625%	Preplant	30.2	1.7	3.3
5	Guardsman	2.5	Preplant	37.4T	0.3T	6.3
6	Guardsman	2.5	Pre	49.7T	0.3T	5.0
7	Guardsman	2.5	Post	28.1	0.0T	15.3
8	Optil+Poast+COC: Laddock+28%UAN+COC	1.5, 0.19, 0.625% 1.04, 5.0%, 1.25%	Preplant:Post	31.8	0.0T	6.3
9	BAS 514	0.25	Pre	28.8	0.7	3.7
10	BAS 514+Atrazine	0.25, 2.0,	Pre	39.3T	0.0T	2.0
11	Frontier: Laddock+28%UAN	1.4, 1.04, 5.0%	Pre:Post	51.6T	0.0T	4.3
12	Check	—	—	15.1	2.0	7.7
	LSD (0.05)			22.2	1.4	n.s.d.

*Adjusted moisture to 15.5%

contain atrazine. All atrazine substitutes gave better control with the addition of atrazine. With the exception of treatments containing products costing several times the price of atrazine, these top yields were not achieved without tankmixes containing at least 1 lb of atrazine.

EFFECTS OF PLANT POPULATION AND WEED CONTROL ON NO-TILL SUNFLOWER

by
Curtis Thompson and Alan Schlegel

SUMMARY

Herbicide options in sunflower are limited especially, in reduced- or no-till cropping systems. Increasing populations from 12,000 to 30,000 plants/acre increased weed control from 0 to 50% in sunflowers not treated with herbicides. Increasing plant population and cultivation gave 60 to 85% control of kochia and pigweed species, respectively. Prowl in combination with high sunflower population gave excellent weed control. Weeds were present in low densities, 1 to 2 plants/sq yd.

INTRODUCTION

Research has shown that a winter wheat - summer row crop - fallow rotation is more profitable and less risky than wheat - fallow especially when the summer crop is planted no-till into winter wheat stubble. Good weed control is essential to optimize production and profits. No-till enhances efficiency of moisture storage by increasing snow movement and reducing run-off and evaporation from the soil. No-till planting of sunflower provides additional challenges, because most registered herbicides require incorporation. Currently, no postemergence broadcast herbicides are available for broadleaf weed control in sunflower.

Row crop cultivation can reduce weed competition and increase yield potential, but moisture loss following cultivation can be a concern. If cultivation has no effect on yields, then the moisture loss in a cultivated system is likely less than the moisture utilized by weeds in a noncultivated system.

This experiment evaluated weed control efficacy and sunflower yields as influenced by planting rate and various combinations of row crop cultivation and herbicide treatments.

PROCEDURES

Experiments were established in 1995 and 1997 in west central Kansas near Tribune in no-till wheat stubble. Treatments were arranged as a split plot with main plots being plant population by herbicide and subplots being cultivation. Roundup at 0.75 lb ai/acre was broadcast applied to the entire area at planting. Sunflowers were planted at 12,000; 18,000; 24,000; and 30,000 seeds/acre in 30-inch rows with a 4-row Model 7300 John Deere planter on June 21, 1995 and May 31, 1997, respectively. Sunflower hybrids were Mycogen 685 in 1995 and Pioneer 6300 in 1997. Prowl at 1.25 lb ai/acre was applied preemergence on the appropriate treatments. Poast + methylated seed oil at 0.2 lb ai + 2 pints/acre were applied postemergence on July 27, 1995 and July 4, 1997 on the appropriate treatments. Cultivation treatments were implemented on July 17, 1995 and June 30, 1997. Weed control was evaluated visually prior to sunflower harvest. Plants in the two center rows of four-row plots were counted and harvested for yield on October 19, 1995 and September 19, 1997. All treatments were replicated four times.

RESULTS AND DISCUSSION

Sunflower population was affected by planting rate in both years (Table 1). The difference between the intended and actual populations increased as the intended population increased. Only at the 12,000 seed rate was the intended population met. Cultivation did not affect sunflower plant population. Herbicide treatment affected final population in 1997. Sunflower population was slightly lower with the Prowl treatment than with the no-herbicide treatment; however, the difference would be insignificant to sunflower yield or weed control.

Table 1. Sunflower population response to planting rate and method of weed control, west central Kansas.

1995

Planting Rate	No Herbicide Cultivated No	No Herbicide Cultivated Yes	No Herbicide Avg	Prowl Cultivated No	Prowl Cultivated Yes	Prowl Avg	Prowl/Poast Cultivated No	Prowl/Poast Cultivated Yes	Prowl/Poast Avg	Overall Avg
	(plants/a ÷ 1000)									
12,000	12.0	11.6	11.8	11.0	13.3	12.2	11.4	12.8	12.1	12.0
18,000	17.6	17.0	17.3	14.6	15.4	15.0	16.2	18.0	17.1	16.5
24,000	18.7	19.7	19.2	21.4	20.1	20.8	19.2	19.5	19.3	19.8
30,000	23.2	24.2	23.7	23.3	24.7	24.0	23.3	24.8	24.0	23.9
Average	17.9	18.1	18.0	17.6	18.4	18.0	17.5	18.8	18.2	

No-cult avg = 17.7 Cult avg = 18.4

$LSD_{0.05}$ Planting rate = 2.1 All other interactions were not significant.

1997

Planting Rate	No Herbicide Cultivated No	No Herbicide Cultivated Yes	No Herbicide Avg	Prowl Cultivated No	Prowl Cultivated Yes	Prowl Avg	Prowl/Poast Cultivated No	Prowl/Poast Cultivated Yes	Prowl/Poast Avg	Overall Avg
	(plants/a÷1000)									
12,000	14.4	13.9	14.1	14.7	11.6	13.1	12.6	12.8	12.7	13.3
18,000	16.4	16.9	16.7	15.1	15.7	15.4	16.2	15.6	15.9	16.0
24,000	19.0	19.7	19.4	17.1	16.9	17.0	21.0	18.9	20.0	18.8
30,000	21.1	21.4	21.3	19.8	18.9	19.3	19.8	21.6	20.7	20.4
Average	17.8	18.0	17.9	16.7	15.8	16.3	17.4	17.2	17.3	

No-cult avg = 17.3 Cult avg = 17.0

$LSD_{0.05}$ Planting rate = 1.1 Herbicide = 1.0 All other interactions were not significant.

In 1997, the best yields were attained with sunflowers planted at 12,000 seeds/acre (Table 2). In both years, yields tended to decrease as sunflower population increased; however, differences were quite small (Table 2). Sunflower populations should be sufficiently high to prevent the development of large sunflower heads (greater than 8 inches in diameter), which generally have more potential for lodging and increased harvest losses. Weed densities were low and did not affect sunflower yield. Therefore, neither cultivation nor herbicide treatment affected sunflower yield in either year of the experiment. Moisture loss from cultivation was not sufficient to reduce sunflower yields. If weed densities had been greater, cultivation likely would have provided an increase in sunflower yield. In 1995, yields were very low because of dry weather conditions and bird damage.

Table 2. Sunflower seed yield response to planting rate and method of weed control, west central Kansas.

1995

Planting	No Herbicide			Prowl			Prowl/Poast			Overall
	Cultivated			Cultivated			Cultivated			
Rate	No	Yes	Avg	No	Yes	Avg	No	Yes	Avg	Avg
	(lbs/a, at 10% moisture)									
12,000	410	250	330	290	240	270	440	290	360	320
18,000	220	400	310	290	280	290	350	250	300	300
24,000	200	180	180	440	330	380	230	280	250	280
30,000	270	410	340	290	240	260	260	180	220	280
Avg	270	310	290	330	270	300	320	250	280	

No-cult avg = 310 Cult avg = 280

$LSD_{0.05}$ No interactions were significant.

1997

Planting	No Herbicide			Prowl			Prowl/Poast			Overall
	Cultivated			Cultivated			Cultivated			
Rate	No	Yes	Avg	No	Yes	Avg	No	Yes	Avg	Avg
	(lbs/a at 10% moisture)									
12,000	2070	2100	2090	2510	2290	2400	2320	2290	2300	2260
18,000	2050	2140	2090	2190	2060	2130	2490	2230	2360	2190
24,000	1700	2080	1890	2240	2140	2190	2060	2010	2030	2040
30,000	2050	2000	2020	1800	1650	1720	2010	2230	2120	1960
Avg	1970	2080	2020	2180	2030	2110	2220	2190	2200	

No-cult avg = 2120 Cult avg = 2100

$LSD_{0.05}$ Planting rate = 200 All other interactions were not significant.

Kochia can be a serious and difficult weed to control in sunflower. In these experiments kochia densities were 1 to 2 plants/sq yd. Cultivation alone provided approximately 50% kochia control (Table 3). In 1995, kochia control was best at the 30000 sunflower seed rate when evaluations were averaged over herbicide and cultivation treatments. The higher planting rates and cultivation provided better kochia control within the no herbicide plots, and Prowl provided excellent kochia control regardless of the sunflower planting rate or cultivation treatment. Poast is a grass herbicide and had no effect on kochia or the pigweed species.

Responses of redroot and tumble pigweed were similar to those observed with kochia (Table 4). Cultivation alone controlled pigweed about 50%. The addition of Prowl into the system increased pigweed control to greater than 80% in 1995 and greater than 90% in 1997. Timely rainfall after application resulted in excellent pigweed control in 1997, regardless of population or cultivation. In 1995, cultivation was required to attain 90% pigweed control.

Table 3. Kochia response to sunflower planting rate and method of weed control, west central Kansas.

1995

Planting Rate	No Herbicide Cultivated No	No Herbicide Cultivated Yes	No Herbicide Avg	Prowl Cultivated No	Prowl Cultivated Yes	Prowl Avg	Prowl/Poast Cultivated No	Prowl/Poast Cultivated Yes	Prowl/Poast Avg	Overall Avg
					(% control)					
12,000	0	40	20	61	97	79	87	91	89	63
18,000	29	70	49	53	95	74	70	96	83	69
24,000	13	62	37	62	94	78	67	99	81	65
30,000	28	83	55	89	97	93	76	99	88	79
Average	17	64	40	66	96	81	74	96	85	

No-cult avg = 52 Cult avg = 85

$LSD_{0.05}$ Planting rate = 13 Cultivation = 8 All other interactions were not significant.

1997

Planting Rate	No Herbicide Cultivated No	No Herbicide Cultivated Yes	No Herbicide Avg	Prowl Cultivated No	Prowl Cultivated Yes	Prowl Avg	Prowl/Poast Cultivated No	Prowl/Poast Cultivated Yes	Prowl/Poast Avg	Overall Avg
					(% control)					
12,000	4	74	39	91	95	93	88	93	90	74
18,000	52	79	65	85	97	91	95	94	95	84
24,000	36	90	63	92	95	93	94	95	95	84
30,000	43	81	62	96	96	96	96	97	97	85
Average	34	81	57	91	96	93	93	95	94	

No-cult avg = 73 Cult avg = 90

$LSD_{0.05}$ Planting rate = 6 Herbicide = 6 PR x Herb = 11 Cultivation = 4 Herb x Cult = 8
All other interactions were not significant.

Table 4. Redroot and tumble pigweed response to sunflower planting rate and method of weed control, west central Kansas.

1995

Planting Rate	No Herbicide Cultivated No	Yes	Avg	Prowl Cultivated No	Yes	Avg	Prowl/Poast Cultivated No	Yes	Avg	Overall Avg
	(% control)									
12,000	0	44	22	70	100	85	83	83	83	63
18,000	36	73	54	64	99	81	78	98	88	74
24,000	13	76	44	79	94	86	89	100	94	75
30,000	30	91	60	96	99	97	93	100	97	85
Average	20	70	45	77	98	87	86	95	90	

No-cult avg = 61 Cult avg = 88

$LSD_{0.05}$ Herbicide = 11 Planting rate = 12 Cultivation = 8 Herb x Cult = 14
All other interactions were not significant.

1997

Planting Rate	No Herbicide Cultivated No	Yes	Avg	Prowl Cultivated No	Yes	Avg	Prowl/Poast Cultivated No	Yes	Avg	Overall Avg
	(% control)									
12,000	3	80	41	94	95	95	91	91	91	76
18,000	52	85	69	92	97	94	97	97	96	86
24,000	39	90	64	94	96	95	94	95	94	84
30,000	44	84	64	96	96	96	95	97	96	85
Average	34	85	59	94	96	95	94	95	94	

No-cult avg = 74 Cult avg = 92

$LSD_{0.05}$ Planting rate = 7 Cultivation = 4 PR x Herb = 12 Herbicide = 6
Herb x Cult = 7 PR x Herb x Cult = 15 All other interactions were not significant.

WEED CONTROL FOR NO-TILL DRYLAND GRAIN SORGHUM IN WESTERN KANSAS

by
Curtis Thompson and Alan Schlegel

SUMMARY

Sorghum yields were highest when broadleaf weeds were controlled with preemergence or post-emergence treatments. Control of kochia and tumble pigweed was essential to attain highest sorghum yields. Milopro, which is propazine and in the same chemical family as atrazine, provided the highest grain sorghum yield. Guardsman and Bicep Lite II controlled both broadleaf and grassy weeds. Permit did not provide good control of kochia or tumble pigweed; thus, sorghum yields were low. Ally + NIS, which is not a registered herbicide in sorghum, caused significant crop injury, and even though it controlled all broadleaf weeds except kochia, sorghum yields were low.

INTRODUCTION

The greatest factor limiting production of dryland sorghum in western Kansas is soil moisture. No-till increases the efficiency of moisture storage, which, in turn, has increased grain production. Control of broadleaf and grass weeds is essential in order that the benefits of this no-till system can be translated into increased grain production. Grass problems tend to increase in the no-till wheat-sorghum-fallow system. This study at Tribune evaluated pre and postemergence herbicides for control of broadleaf and grass weeds in grain sorghum planted no-till into wheat stubble.

PROCEDURES

Grain sorghum, 'Pioneer 8505' Concep-treated seed, was planted no-till into wheat stubble at 30,000 seeds/acre in 30 inch rows on June 1. Preemergence (PRE) treatments were applied on June 2 with a hand-boom CO_2-pressurized plot sprayer delivering 20 gpa. Roundup Ultra at 24 oz/acre was broadcast over the entire experiment after sorghum planting to control all emerged weeds. Postemergence (POST) treatments were applied on June 28 to 5-collar sorghum approximately 6 to 7 inches tall as previously described. The sizes of weeds treated were: 1 to 3 inches for grassy weeds, 0.5 to 3 inches for tumble pigweed, 1 to 6 inches for redroot pigweed, 1 to 4 inches for kochia, and cotyledon to 3-inch-diameter for puncturevine. Weather conditions, soil characteristics, and weed densities are presented in Table 1. Crop injury and weed control were evaluated visually on July 9. October snowfall caused severe lodging and delayed sorghum harvest until January 21, 1998. Plots were 10 by 30 ft; however, grain was harvested from 2 rows 27 ft long with a plot combine.

RESULTS AND DISCUSSION

Sorghum yields ranged from 39 to 94 bu/acre and were correlated strongly to the levels of control for tumble pigweed and kochia (Table 2). When broadleaf weeds were controlled and grass weeds suppressed, sorghum yielded better than 70 bu/acre. Sorghum yielded the lowest when left untreated or treated with Permit, Ally, or some of the Peak treatments.

Sorghum was injured by preemergence atrazine and atrazine tank mixes; however, grain yields were not affected. Several postemergence treatments also injured sorghum, but only Ally + NIS appeared to reduce grain yield. Tough, a postemergence herbicide for corn, caused considerable injury but appeared to have little effect on final yield. Ally and Tough are not registered herbicides for sorghum and, thus, should not be used.

Redroot pigweed was controlled with all herbicide treatments. Tough and Permit gave less redroot pigweed control than the other herbicides. Tumble pigweed was controlled 90% or more with most herbicides but not Permit, Tough, or Peak+Banvel. Puncturevine was controlled 80% or more with most herbicides except Tough. Atrazine tended to control more puncturevine when applied postemergence than when applied preemergence. Kochia, one of the more difficult broadleaf weeds to control, was not controlled adequately with Permit, Peak, or Ally (0.05 oz product/acre).

Low infestations of grasses were controlled with all preemergence applications of atrazine or Milopro alone or tanked mixed with a grass herbicide. Postemergence treatments did not control grasses. Atrazine alone or tank mixed with other herbicides gave some suppression of grass when applied postemergence.

Table 1. Weather conditions, soil information, and weed densities, no-till sorghum study, Tribune, KS.

Variable		Preemergence Surface	Postemergence
Application date		6/2/97	6/28/97
Time of day		6:00 pm	1:00 pm
Air temperature (F)		71 F	85 F
Wind speed mph (direction)		4 (S)	3 (S)
Relative humidity		66%	20%
Soil surface moisture		Dry	Dry
Weed densities / yd^2:			
	Stinkgrass	3	
	Grassy sandbur	2	
	Witchgrass	3	
	Tumble pigweed	4	
	Redroot pigweed	2	
	Kochia	1	
Soil	pH	7.8	
	OM (%)	1.7	
	Classification	Ulysses silt loam	

Table 2. Weed control in no-till sorghum, Tribune, KS, 1997.

Treatment	Rate	Timing	Sorghum Yield	Sorghum Moisture	Sorghum Test weight	Sorghum Injury	Redroot Pigweed	Tumble Pigweed	Puncture Vine	Kochia	Witch-grass	Sandbur	Stink-grass
	(lb ai/a)		(bu/a)	(%)	(lb/bu)	(%)	% control						
Atrazine	1.0	PRE	84	18.0	58.3	15	99	100	83	100	99	100	100
Milopro	1.2	PRE	94	18.1	58.1	3	98	100	92	100	98	94	100
Guardsman	2.15	PRE	88	18.1	58.0	14	100	100	89	100	100	98	100
Bicep Lite II	2.5	PRE	79	18.5	57.7	11	100	100	91	100	100	100	100
Peak	0.018	POST	70	19.1	56.8	0	98	90	97	50	0	0	0
COC	2.0 pt	POST											
Peak	0.027	POST	56	17.7	58.9	0	98	90	98	56	3	3	5
COC	2.0 pt	POST											
Peak	0.036	POST	64	18.1	58.6	0	99	91	100	78	0	3	5
COC	2.0 pt	POST											
Peak	0.018	POST	67	18.0	58.4	3	100	100	99	98	24	28	20
Atrazine	0.75	POST											
COC	2.0 pt	POST											
Peak	0.018	POST	54	18.1	58.0	9	99	73	99	97	3	3	5
Banvel	0.125	POST											
NIS	0.25 % v/v	POST											
Tough	0.94	POST	76	18.3	56.7	35	91	78	54	85	16	14	5
Permit	0.031	POST	39	18.7	56.3	0	90	35	91	24	1	1	3
NIS	0.25% v/v	POS											

Table 2. Weed control in no-till sorghum, Tribune, KS, 1997, continued.

			Sorghum										
Treatment	Rate	Timing	Yield	Moisture	Test weight	Injury	Redroot Pigweed	Tumble Pigweed	Puncture Vine	Kochia	Witch grass	Sandbur	Stink grass
	(lb ai/a)		(bu/a)	(%)	(lb/bu)	(%)	% control						
Marksman	1.0	POST	82	18.3	57.4	14	98	96	95	98	18	18	35
Buctril & Atrazine	0.75	POST	77	17.8	58.9	0	98	95	95	99	21	21	25
Atrazine	1.0	POST	73	18.0	57.9	2	99	100	91	97	53	50	55
Ally	0.0019	POST	50	18.1	57.6	42	99	98	98	59	3	5	5
NIS	0.25% v/v	POST											
Shotgun	0.81	POST	78	18.2	57.8	29	100	97	98	96	30	30	20
Untreated			49	18.0	57.8	----	----	----	----	----	----	----	----
LSD $_{(.05)}$			21	0.9	1.8	7	3	20	13	15	12	11	19

RESPONSE OF NARROW-ROW CORN TO SIMULATED HAIL

by
Merle Witt

SUMMARY

In this study, narrow rows for corn did not affect the amount of yield loss caused by early-season defoliation.

PROCEDURE

Corn was evaluated for grain yield loss caused by simulated hail defoliation at two stages (8-leaf and 12-leaf). This was done in combination with two crop row spacings (15 in. and 30 in.). Additionally, two hybrids were used: 'Asgrow RX707,' a 109-day maturity hybrid, and 'Pioneer 3162,' a 114-day maturity hybrid.

Corn was planted at Garden City on April 25, 1996 with a White Air Seeder at 33,000 seeds/acre. Resulting stands of 30,000 plants per acre were kept weed free with Prowl/Bladex herbicide. Defoliation of 50% of the leaf area on selected plots was accomplished on June 4, 1996 for the 8-leaf (8L) stage treatments and on June 28, 1996 for 12-leaf (12L) stage treatments. The two center rows of four row plots including four replications were hand harvested on October 14, 1996.

RESULTS AND DISCUSSION

Data indicated about a 4% reduction in grain yield at the 8L stage from 50% defoliation when averaged over both hybrids and both row spacings (Table 1). An approximate 10% grain yield reduction was observed for the 12L stage with 50% defoliation when averaged over both hybrids and both row spacings. Yields were about 4% more with the 15-in. row spacing compared to the 30-in. row spacing, when averaged over both hybrids and all treatments.

The results suggest that narrow rows for corn did not affect the amount of yield loss caused by early-season defoliation. However, the narrow row spacing was beneficial to corn yields, regardless of whether or not defoliation occurred.

Table 1. Grain yields of defoliated corn using two hybrids at two row spacings, Garden City, KS, 1996.

Treatment	Asgrow RX707	Pioneer 3162
	bu/acre	
30-in. rows - check	217	269
30-in. rows - 50% defoliated at 8L	204	256
30-in. rows - 50% defoliated at 12L	189	244
15-in. rows - check	226	277
15-in. rows - 50% defoliated at 8L	213	272
15-in. rows - 50% defoliated at 12L	202	249
LSD (5%) Row spacing	8.5	15.0
LSD (5%) Defoliations	8.3	9.7
LSD (5%) Row spacing X Defoliation	11.7	13.7

EFFECT OF SIMULATED HAIL ON CORN HYBRID ISOLINES WITH RESISTANCE TO EUROPEAN CORN BORER

by
Merle Witt and Larry Buschman

SUMMARY

This study evaluated yield loss caused by simulated hail defoliation of new corn hybrids with and without a Bt gene addition for European corn borer resistance. Defoliation at 80% of leaf area was done at the 15-leaf stage. Grain yield reductions were similar for both hybrids with and without a Bt gene event.

INTRODUCTION

New technology has entered the corn market with European corn borer (ECB)-resistant corn. Significant losses occur with ECB damage, so that much time and money is spent to scout and treat for ECB. The resistant corn has the potential to reduce yield losses that result from both first-generation and second-generation ECB infestations. Corn with ECB resistance contains a gene from the naturally occurring soil bacteria *Bacillus thuringiensis* (Bt). An added Bt gene causes the corn plant to produce a protein, that is toxic to ECB larvae when they ingest plant tissue. Because Bt corn hybrids contain an exotic gene, they are called transgenic plants. Two of the several Bt events that have been created for use in hybrid corns were included in this project.

This study was conducted with sponsorship by the National Crop Insurance Services to evaluate yield loss caused by simulated hail defoliation of new corn hybrids with and without the Bt gene. Two pairs of isogenic hybrids were selected. One hybrid (NK 7590) was provided by Novartis Seeds. NK 7590 is a 114-day hybrid with Bt 11 (Maximizer) as its Bt-event source of ECB resistance. The second hybrid from Golden Harvest (G.H. 2530) is a 113-day hybrid that utilizes Mon 810 (Yieldgard) as its Bt-event source of ECB resistance.

PROCEDURES

Corn was planted at the Southwest Research-Extension Center, Garden City, KS on May 7, 1997 with a White Air Seeder at 33,000 seeds/acre. Resulting stands of 30,000 plants/acre were kept weed free with Prowl/Bladex herbicide. Defoliation at 80% of the leaf area on selected plots was accomplished on July 8, 1997 at the 15-leaf growth stage. The insecticide Capture was applied aerially at a 5 oz/acre rate over the entire study on August 5, 1997. The two center rows of four row plots including three replications were machine harvested on October 17, 1997

RESULTS AND DISCUSSION

Grain yields at 15.5% moisture are shown in Table 1. The analysis of variance results for this split

Table 1. Grain yields of ECB-resistant corn hybrids, Garden City, KS, 1997.

		Defoliation at 15-Leaf			Control		
Hybrid	Bt Source	% lodging	% H_2O	bu/a	% lodging	% H_2O	bu/a
NK 7590	—	77%	11.4	136.3	1%	12.2	220.3
NK 7590Bt	Bt 11	77%	11.8	155.9	2%	11.6	231.7
G.H.2530	—	40%	10.8	131.4	0	10.6	216.8
G.H.2530Bt	MON 810	43%	11.1	147.2	0	11.5	229.1

Table 2. Analysis of variance results from ECB corn hybrid defoliation study.

Source	Degrees of Freedom	Means Square	Probability of Difference
Replication	2	370.93	
Hybrids	1	144.06	n.s.
Error a	2	425.32	
Bt vs non-Bt	1	1,317.20	**
Error b	2	33.97	
Hybrid x Bt	1	2.94	n.s.
Error c	2	73.99	
Defoliation	1	40,131.08	**
Hybrid x defoliation	1	20.91	n.s.
Bt x defoliation	1	51.04	n.s.
Hybrid x Bt x defoliation	1	8.17	n.s.
Error d	8	557.29	
Total	23	43,136.90	

n.s. = nonsignificant, ** = significant at the .01 level.

split strip-plot study are given in Table 2.

This initial research indicates that two new corn hybrids, each with a different Bt gene event added, were both effective at controlling first and second generation ECB. In fact, the Bt hybrids showed a 15 bu/acre increase in grain yield above that by their counterpart non-Bt near isogenic hybrids despite the fact that Capture insecticide was applied aerially in timely fashion to the entire study.

Defoliation of approximately 80% at the 15-leaf stage caused an overall average grain yield reduction of 37%. Reductions were similar with the two hybrids with or without the added Bt gene. Thus, presence or absence of a Bt gene event did not affect yield losses caused by simulated hail.

ACKNOWLEDGMENTS

The staff of the Southwest Research-Extension Center and Kansas State University appreciate and acknowledge the following companies, foundations, and individuals for their support of the research that has been conducted during the past year.

Donations:

American Cyanamid
Asgrow Seed Company
Bayer Chemical
Cargill Hybrid Seeds
DeKalb Genetics Corp.
Dow Elanco
Drussel Seeds
DuPont Ag Products
ICI Americas Inc.
ICI Seeds Inc.
Monsanto Co.
NC+ Hybrids
Novartis Seeds, Inc. (CIBA)
Novartis Seeds, Inc.(Northrup King)
Pioneer Hi-Bred Intl.
Prairie Pea & Bean
Pueblo Chemical
Resource Seeds, Inc.
Ruffin Micronutrient
Terra International, Inc.
Zeneca Ag Prod.

Grant Support:

AgrEvo Co.
Amilar International
American Cyanamid
BASF Corp
Bayer Chemical
DeKalb Genetics Corp.
Dow Elanco
DuPont Ag Prod.
Elf ATO Chem
Fluid Fertilizer Foundation
FMC Corp.
Gustafson Inc.
HybriTech Seed Int. Inc.
Kansas Fertilizer Fund
Monsanto Co.
Morehouse Agronomy Research Fund
Mycogen Seeds
National Crop Insurance Services
National Sunflower Association
Novartis Seeds, Inc.
Novartis Seeds, Inc., (CIBA)
Potash and Phosphate Institute
Rhone Poulenc Ag. Co.
State Board of Agriculture:
Sorghum Commission
Stockhausen, Inc.
Uniroyal Chemical
USDA-Cooperative State Research Service
USDA-NCR
USDA/ARS
Valent USA Corp.
Zeneca Ag Prod.

Cooperators:

Dechant Farms
Garden City Company
Warren Hatzenbuehler
Nicholson & Nicholson
Reimer Farms
David Robb
Rome Farms
Ron Taylor
Todd Tobin
Clayton Unruh
Donnie Young

Performance Tests:

AgriPro Seeds, Inc.
AGSECO
Allied Seed Cooperative Producers
American White Wheat Producers Assn.
Asgrow Seed Co.
BoJac Hybrid Corn Co.
Mike Brayton Seeds
Cal/West Seeds
Cargill Hybrid Seeds
Casterline Seeds
Crosbyton Seed Co.
DeKalb Genetics Corp.
Delange Seed
Drussel Seed & Supply
Freedom Seed Co.
Garden City Seeds, Inc.
Garst Seed Co.
Genetic Resources, Inc.
Germain's Seeds
Giant Seed Co.
Golden Harvest
Golden World
Great Lakes
Great Plains Research Co.
Greenbush Seed and Supply
High Plains Hybrids
Hoegemeyer Hybrids
Hybritech Seed
Jerry Weaver Seeds
J.C. Robinson Seed Co.
Kaystar Seed
L.G. Seeds
Midland Seeds
Midwest Seed Genetics, Inc.
Miller Preferred
MSG (Ohlde)
Mycogen Plant Sciences
NC+ Hybrids
Novartis
Ottilie Seed Farms
Patriot Seed Co.
Pioneer Hi-Bred Intl.
Sharp Bros. Seed Co.
Star
Stauffer Seed
Stine Seed Farms
Terra
Triumph Seed Co., Inc.
Wilbur-Ellis Co.
Wilson Hybrids, Inc.
W-L Research

Charles Norwood - Agronomist - Dryland Soil Management. Charles 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.

Curtis Thompson - Extension Agronomist, Curtis received his M.S. from North Dakota State University and his Ph.D from the University of Idaho. He joined the staff in 1993. His extension responsibilities include all aspects of soils and field crop production.

Todd Trooien - Agricultural Engineer. Todd received his M.S. from South Dakota State University and Ph.D. from Colorado State University. He joined the staff in 1996. Research interests include technology and management for more efficient use of water.

Carol Young - Extension Home Economist and Program Specialist. Carol received her M.Ed. from Wichita State University in educational administration. She joined the staff in 1982 with Extension agent experience in Edwards, Sumner, and Osage counties. Carol promotes programs that benefit families and communities and teaches planning, leadership, and citizen involvement skills.

Merle Witt - Agronomist - Crop Specialist. Merle received his 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.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan 66506

SRP 814 August 1998