Progress Report

Areawide IPM of the Russian Wheat Aphid and Greenbug

A Summary of Program Activities During Phase I (October 2001 - September 2002) and the First Year of Phase II (October 2002 - September 2003)

(Submitted December 8, 2003)

Executive Summary

This report includes demonstration, evaluation, and research activities of the AWPM of the Russian wheat aphid and Greenbug project for Phase I (October 1, 2001 – September 30, 2002) and the first year of Phase II (October 1, 2002 – September 30, 2003). During this time period we made greater progress towards completing project objectives than originally described in our project proposal. However, there were unanticipated developments, such as detection of a new strain of the Russian wheat aphid, which required minor shifts in program direction. This progress report does not include information on organizational meetings and activities. However, the end products of many of those meetings and activities are the demonstration, evaluation, and research activities summarized in the report. Integration of information from all demonstration and evaluation activities is incomplete in the report, however such integration is an ongoing activity of the AWPM team. The most significant AWPM activities and observations during the reporting period are as follows:

1) Greenbug populations were abnormally low throughout the region during the 2002-2003 growing season. In spite of the low greenbug populations, which made it difficult to assess differences in greenbug populations between diversified and wheat only croppings systems, natural enemies of the greenbug were generally more abundant and diverse in diversified as compared to wheat only systems. The difference was more evident when the cropping system was viewed from the scale of the landscape within which a demonstration field was embedded rather from a within field scale. In other words, crop rotation at a whole farm scale or even a multi-farm scale was associated with greater populations of greenbug natural enemies in wheat fields, and crop rotation at a within field scale was either less important or overshadowed by the effects of diversification at the larger scale.

2) A new strain of Russian wheat aphid, which causes damage to previously resistant winter wheat varieties, appeared in AWPM demonstration zones 1 and 2. An important and previously unanticipated objective of the AWPM project will be to determine the geographic extent and economic impact of the new strain, and to assess existing sources of resistance against the new strain. Furthermore, the AWPM program will serve as a platform for technology transfer of previously developed pest management tools, e.g. biological control, sequential sampling and economic thresholds, and an area-wide pest alert and forecasting network, which are essential components for sustainable management of the aphid.

3) Socioeconomic evaluation accomplishments included recruiting 147 wheat producers to participate in project, and completing focus groups and cost-of-production interviews with those participants. During the first year of Phase II (January and March, 2003), 20 focus groups were conducted, each involving 6-10 producers at a particular demonstration location. Focus group discussions were transcribed and transcripts were entered into a database program and coded for further synthesis and analysis. We are still in the process of generating a complete focus group summary report. We also completed the first of four annual cost-of-production interviews with all but two of the 147 participants. We are currently generating farm budgets from interviews, which will allow us to compare the costs and returns associated with wheat-only and diversified cropping systems. This baseline data will be important background information for evaluating changes in production strategies occurring in the suppression region as a result of the program.

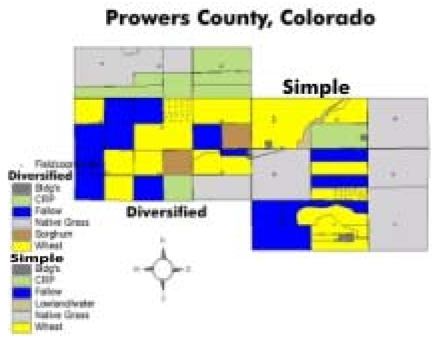
4) Important research and development progress included: A) GIS mapping of all demonstration sites to facilitate quantitative evaluation of effects of field and and landscape scale cropping system diversity on greenbugs, Russian wheat aphids, and other pests, and the effectiveness of biological control; B) field scale tests using multi-spectral remote sensing to detect greenbug infestations in wheat were completed, which showed promise for developing an area-wide system for monitoring greenbug infested fields; C) field and laboratory studies to determine the dynamics of aphid natural enemies in diversified and wheat only cropping systems were initiated to facilitate prediction of cropping system configuration on biological control of greenbugs and Russian wheat aphids; and D) an Oracle/Visual Basic database management system was developed for project wide assimilation of demonstration site data and near real time dissemination of pest status information to growers throughout the suppression area.

Contents

1. Demonstration Component Summaries

a. Colorado Demonstration Sites

Prowers County, CO
Phase II, Year 1 (2002-2003)
Written by Laurie Kerzicnik



Crops Involved in the Rotation

Simple-rotation field -Wheat

The field to the right is a grower who uses simple rotation. He has strips of wheat/fallow, and 80 acres were used for sampling.

Diversified Field-Wheat & Sorghum

The grower to the left grows wheat and grain sorghum, which is a diversified field. The wheat sampled was 160 acres of Prairie Red. The sorghum was also 160 acres.

Aphid Overview

In the wheat, aphids were sampled monthly from March through June. The dominant aphid for both cooperators was *D. noxia* (Table 1). *Rhopalosiphum padi* was also present in low densities. The grower of the simple-rotation field had more *D. noxia* in his field in early June, but aphid densities were extremely low and far from damaging levels. It is difficult to compare aphid densities with both fields, as populations were minimal.

Table 1. No. aphids for either field in wheat. Total no. aphids= sum of aphids for 25, 1-ft rows, measured by Berlese funnels.

Date	Aphid	Diversified	Simple
3/26/2003	*D. noxia*	4	14
	S. graminum	0	0
	R. padi	0	0
4/24/2003	*D. noxia*	77	15
	S. graminum	0	0
	R. padi	0	18
5/14/2003	*D. noxia*	33	36
	S. graminum	0	0
	R. padi	20	3
6/10/2003	*D. noxia*	53	183
	S. graminum	0	1
	R. padi	0	0

In the sorghum, aphids were sampled during late whorl, flowering, and grain fill in the diversified field. *Schizaphis graminum* was present in early August and were replaced by *R. maidis* in October (Table 2). Aphid numbers were relatively low; however, greenbug damage was evident by red spotting on several of the plants.

Table 2. No. aphids per 10 benchmark samples at the diversified field (grain sorghum) (3 plants per benchmark).

	Crop Stage	*S. graminum*	*R. maidis*
8/12/03	Late Whorl	236	0
9/15/03	Flowering	10	0
10/8/03	Grainfill	0	250

Natural Enemies

In the wheat, predators were abundant. The major predators are shown in Table 3. Spiders comprise the greatest number of predators, followed by nabids, coccinellids, and minute pirate bugs, *Orius* sp. This pair of demonstration sites is interesting because predator densities are higher with the diversified grower in all categories.

Table 3. No. predators in wheat for either field. Each date represents a total for 625 sweep net samples per site (at 25 points). (D=Diversified field; S=Simple field)

	Nabidae		Spiders		Coccinellidae		Coccinellidae (imm.)		Green Lacewing		*Orius* sp.	
Date	***D***	***S***	***D***	***S***	***D***	***S***	***D***	***S***	***D***	***S***	***D***	***S***
5/14/03	174	149	564	430	49	10	2	18	0	0	8	8
5/28/03	194	150	237	138	42	27	11	5	3	0	7	9
6/09/03	40	58	148	99	14	9	1	0	0	0	0	0
6/23/03	20	10	49	26	0	0	0	0	1	0	0	0
Total	**428**	**367**	**998**	**693**	**105**	**46**	**14**	**23**	**4**	**0**	**15**	**17**

For sorghum, predators were sampled during late whorl, flowering, and grainfill. Fifty sorghum plants were sampled at each benchmark. Both coccinellids and the spider mite destroyer, *Stethorus punctillum*, were present at all sampling times; however, densities were very low.

Other Pests

The wheathead armyworm appeared in the diversified grower's field on May 14, 2003 in the wheat. Populations increased in sweep net samples for both cooperators after this date (Table 4). Although little is known about the wheathead armyworm, it is known that the first generation larvae feed on foliage before heading and feed on the heads as they develop.

Table 4. No. wheathead armyworms per 625 sweeps for each date and cooperator. (S=Simple field; D=Diversified field)

	S	D
5/14/03	0	2
5/28/03	1072	514
6/9/03	448	317
6/23/03	94	123

In the sorghum, there weren't any major pests present besides aphids. Sampling for headworms was conducted late in the sorghum crop stage, but no headworms were found.

Weeds

Weeds were sampled before wheat jointing, before harvest, and after harvest both within the field and along the borders. Weed densities were close to zero before jointing both within the field and the border for both fields. Before harvest, the conventional grower's field had very few weeds. The diversified grower's field, however, had heavy bindweed infestations in the field but no significant weeds along the border. After harvest, weeds were very high within both fields. Along the field borders, the conventional grower had heavy infestations of *Bromus* sp. and jointed goatgrass along the west. The diversified grower had high infestations of *Bromus* sp. along the southern and eastern borders of his field.

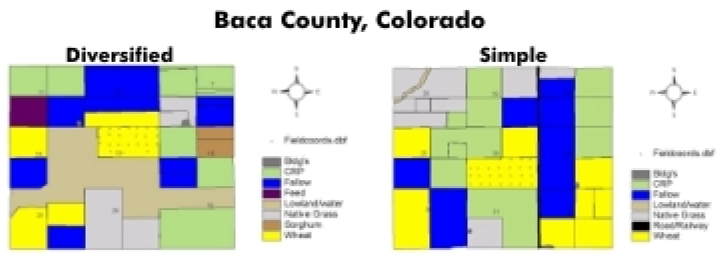
Although we did not sample weeds in sorghum, it should be noted that field sandbur densities were extremely high. The sandburs were present in every area of the field, including the benchmark areas.

Summary

The notable aspect of this pair of sites is the greater density of predators with the diversified grower. The aphid numbers were at a minimum for both cooperators. The wheathead armyworm was present in high densities in late May/June at both sites. Weed densities were high close to harvest within the field, and *Bromus* species and jointed goatgrass were present along the field borders around harvest time.

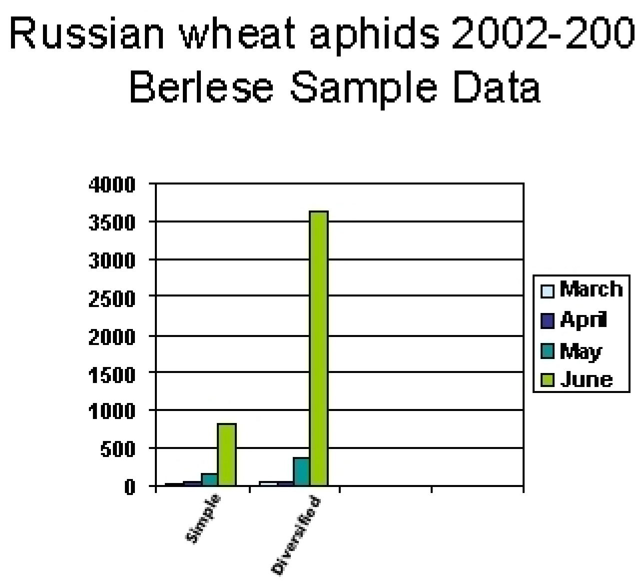
We have made an effort to broaden communications with both growers. When the project started, I met the diversified grower for breakfast to discuss the project. We visited the conventional grower at his home to ask questions and describe the goals of the research. We have provided both cooperators with soil and climatic data for the year. Both cooperators seem genuinely interested in the project and the pests, predators, and weeds we find.

Baca County Colorado
Phase II, Year 1 (2002-2003)
Written by Hayley R. Miller

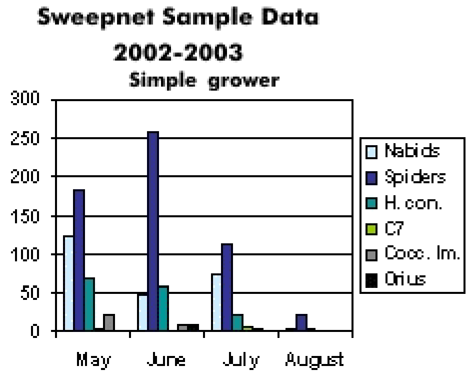


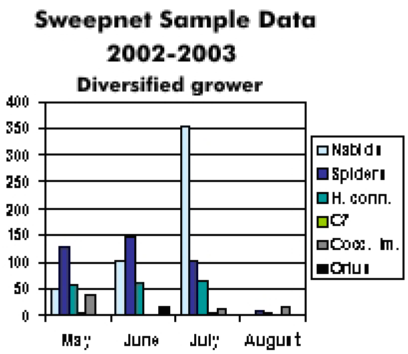
Crops involved in rotation: Wheat-Fallow, Wheat-Sorghum-Fallow
The field on the right is our simple-rotation field, where the cooperator is growing Hard Red winter wheat, Prairie Red and Halt. The field on the left is our diverse field, where the cooperator is growing Hard Red Winter wheat (Certified Prairie Red), rotated with grain sorghum and fallow.

Russian wheat aphid status: Russian wheat aphids were present at both farms. The simple-rotation field had little Russian wheat aphid pressure at the end of May and in June. A biotype of the Russian wheat aphid was found in the diversified field. Four months of Berlese sample data shown below were taken from 25 1ft. row samples at each location. When aphids were found samples were taken and put in emergence canisters, no parasitoids were found at either site. This year drought was a problem in wheat production.



Natural enemies:





Twenty-five 180 degree sweeps were taken at each of the 25 points at each location. The majority of natural enemies were nabids, spiders, coccinellids and minute pirate bugs.

Other pests: Simple-In addition to Russian wheat aphids the conventional field had eight Bird Cherry Oat aphids and one greenbug in the April Berlese samples. The table below gives the Berlese samples counts for Banks Grass Mite, Brown Wheat Mite and Thrips.

	27 March	21 April	13 May	9 June
BGM	0	8	6	0
BWM	0	0	12	0
Thrips	0	84	833	676

Twenty-five 180 degree sweeps were taken at each of the 25 points at each location and the number of Wheat Head Army Worms caught is shown in the table below.

	13 May	27 May	10 June	24 June
WHAW	0	70	452	254

Diverse-In addition to Russian wheat aphids the diversified field had 23 Bird Cherry Oat Aphids in the June Berlese samples. The table below gives the Berlese samples counts for Banks Grass Mite, Brown Wheat Mite and Thrips.

	27 March	21 April	13 May	9 June
BGM	0	39	8	0
BWM	0	0	33	0
Thrips	0	275	1569	1699

Twenty-five 180 degree sweeps were taken at each of the 25 points at each location and the number of Wheat Head Army Worms caught is shown in the table below.

	13 May	27 May	10 June	24 June
WHAW	0	341	1305	188

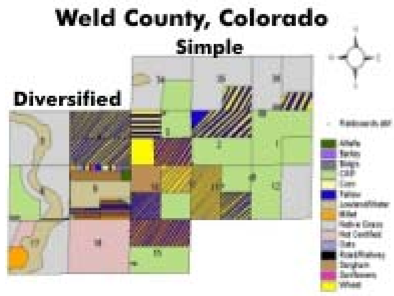
Weed situation in wheat: Zero to fourteen days before jointing there was little weed pressure at either site. Zero to fourteen days before harvest the simple-rotation field had 3 to10+ weeds at each of the 25 sampling points and wheatgrass and jointed goat grass pressure on east and west borders of the field. Zero to 14 days after harvest this field had 1 or 2 patches of volunteer wheat on his west border and patches of *Bromus* species ranging from 1 or 2 plants to 10 or more on north, east and west borders. Zero to fourteen days before harvest the diversified field had 3 to10+ weeds at each of the 25 sampling points and little *Bromus* pressure on the west border of the field. Zero to 14 days after harvest the diversified had high *Bromus* pressure on south, east and west borders and jointed goat grass pressure on all borders.

Sorghum: Fifteen plants were examined at ten points throughout the field and sampled for aphids and beneficial insects. At late whorl stage corn leaf aphid pressure was high at the diversified field, averaging 30 aphids per each of the 15 plants at each of the 10 locations. Nabids, lacewings immature and adults stages, flea beetles, spiders, tenebrionids, coccinellids, plants hoppers, minute pirate bugs, and thrips were all observed in small numbers on the sorghum plants at late whorl and flowering stages. Corn leaf aphid pressure was less at flowering stage averaging 10 aphids per plant. Sorghum was harvested before corn earworm and fall armyworm could be sampled, yield was not obtained due to early harvest.

Weed situation in sorghum: Occasional sandbur nothing of concern.

Summary of overall findings and important observations: A biotype of the Russian wheat aphid was found in the diversified field in Baca County. Wheat head army worm counts were high at both sites. A breakfast meeting was held in Springfield Colorado at the Longhorn Steakhouse to discuss the project status with both growers. The grower with the diversified field was unable to attend due to sorghum planting. The grower with the simple-rotation field, Laurie Kerzicnik and I attended the meeting and relayed important information to both parties such as planting dates, yields, insects and weeds present. Both cooperators are showing interest and enthusiasm in this project. Yield information is not yet complete for both cooperators.

Weld County, CO
Phase II, Year 1 (2002-2003)
Written by Laurie Kerzicnik



Crops Involved in the Rotation

Simple Rotation-Wheat

The grower with the simple-rotation field maintains the wheat/fallow rotation for this pair of demonstration sites. His wheat is in a half-section of stripped wheat/fallow, which equals approximately 160 acres of wheat. The variety planted is primarily Scout 66, although there is a variety trial with several wheat varieties in one of the wheat strips.

Diverse field-Wheat, Millet & Sunflower

This is the grower with the diversified field for this county. This is a unique site because it is part of a USDA/CSU diversified cropping systems study. The purpose of the study is to determine the effect of diverse cropping systems on integrated pest management and the effect of shorter fallow periods on cropping systems.

There are four rotations in this study-wheat/fallow, wheat/millet/fallow, wheat/wheat/corn/corn/sunflower/ fallow, and opportunity cropping. The wheat/fallow and wheat/millet/fallow are rotations that are typically seen in Colorado. For this study, we used four plots of wheat and four plots of millet that were in the wheat/millet/fallow rotation. The plots are replicated such that there are four replications of wheat, four of millet, and four of fallow.

Wheat: We divided our 25 sampling points among the four wheat plots.

Sunflower: This is part of the wheat/wheat/corn/corn/ sunflower/fallow rotation. There were four sunflower plots, and we sampled 15 plants in each plot.

Millet: The millet was not sampled in this study. The millet was harvested due to adverse conditions and was sprayed before the first sampling could occur.

Overview of the Aphid

Aphids were sampled from April through June. The primary aphid is the Russian wheat aphid, *Diuraphis noxia* Mordvilko. The greenbug, *Schizaphis graminum* Rondani, and the bird cherry oat aphid, *Rhopalosiphum padi* L, were also present, but their populations were extremely low. Table 1 shows *D. noxia*, *R. padi*, and *S. graminum* and their densities for each grower. The diversified field had a peak of *D. noxia* in late May where the simple-rotation field had higher densities in June. The simple rotation also had a greater density of *R. padi*.

Table 5. Aphids for Weld County Cooperators, diversified and simple rotation in wheat. Total # aphids=sum of aphids for 25, 1-ft rows, measured by Berlese funnels. (D=Diversified field; S=Simple field)

Date	Aphid	D	S
4/15/2003	*D. noxia*	9	4
	S. graminum	0	0
	R. padi	0	0
5/22/2003	*D. noxia*	911	125
	S. graminum	0	0
	R. padi	0	11
6/26/2003	*D. noxia*	634	889
	S. graminum	4	2
	R. padi	3	34

Natural Enemies

For the diversified and conventional farmers, natural enemies were prevalent in wheat. There are no apparent differences in natural enemy densities between cooperators. Table 2 shows the major predators for wheat from 5/19/03-7/9/03. The dominant natural enemy for both cooperators was *Orius* sp. (minute pirate bug). When populations of *Orius* diminished, nabids, spiders, and coccinellids densities remained constant. The green lacewing was present but at low densities.

Table 6. Predators in wheat for both diversified and conventional. Each date represents a total for 625 sweep net samples per site (at 25 points). *The wheat in the diversified field was harvested before 7/9/03, so there were no sweep net samples for this time. (D=Diversified field; S=Simple field)

	Nabidae		Spiders		Coccinellidae		Coccinellidae (imm.)		Green Lacewing		*Orius* sp.	
Date	***D***	***S***	***D***	***S***	***D***	***S***	***D***	***S***	***D***	***S***	***D***	***S***
5/14/03	6	8	13	14	3	15	0	1	1	0	282	401
5/28/03	23	43	29	15	10	26	2	0	3	0	54	8
6/9/03	20	2	31	11	14	13	0	28	0	0	0	2
6/23/03	*	5	*	15	*	12	*	10	*	0	*	1
Total	**49**	**58**	**73**	**55**	**27**	**66**	**2**	**39**	**4**	**0**	**336**	**412**

Other Pests

In the wheat, brown wheat mites, *Petrobia latens* Mueller, were found at both sites but densities were very low. Thrips were also found at low densities.

For sunflower, surveys were taken twice in August 2003 before the late bud stage to look for the headclipper moth and the grey and red sunflower weevils. The headclipper moth was not present, and the grey and red weevil populations were at a minimum (averaging less than one per head). Sunflower headmoths were sampled two weeks after the plants reached the 5.9 stage, and the headmoths averaged 10-50 per head in the four benchmark areas. At plant maturity, stem weevils and borers were sampled in the stalk. Stem weevils and stem borers densities were low, averaging less than five per head. Overall, the sunflowers looked relatively healthy for dryland cropping, showing little sign of pest infestation or damage.

Weeds

Weed counts were conducted before wheat jointing, before harvest, and after harvest. Before wheat jointing, there were almost no weeds present within either of the growers' fields or along their field borders. Before harvest, weeds were consistently high within the simple-rotation field, averaging about 10 weeds per ½ meter squared. In this field border, *Bromus* sp., jointed goatgrass, and volunteer wheat densities were high. The diversified field had fewer weeds at this time, with an average of three weeds per ½ m^2. However, the field did not have any significant weeds along the field borders. After wheat harvest, weeds were numerous in the conventional grower's field within the 10 most westerly points but declined to about three weeds per ½ m^2 for the remaining 15 sampling points. The field borders maintained high densities of *Bromus* sp., jointed goatgrass, and volunteer wheat. Weeds in the diversified field remained at about three per ½ m^2 throughout the field and low around the field borders.

Summary

For this pair of sites, aphid and natural enemy densities were comparable between the fields. Weed densities were somewhat higher before and after harvest within the field and along the field border for the simple-rotation field. Other pest populations remained low at both sites. Although the millet was harvested before samples could be taken, it does represent the opportunistic approach that most growers take when adverse crop conditions exist.

We have taken measures to extend communications with the cooperators. At the start of the project, we met the grower of the diversified field for breakfast to talk about the project and the work we would conduct in his field. At the beginning of this year, Hayley Miller and I helped the grower of the simple-rotation field plant CSU wheat variety trials at the site where we are sampling; he needed two extra hands to help load the seed. In addition, we have sent both cooperators copies of the soil and climatic data collected at their sites. These extended interactions have helped to establish good contacts with the cooperators and give the project a good name. By providing data and help when necessary, I believe we are returning the favor for the use of their fields. Both growers have taken an interest in the project, attending field days, asking questions while we are in the field, and responding to our information requests.

b. Texas Demonstration Sites

Phase II, Year 1 (2002-2003)
Written by Mustafa Mirik, Jerry Michels, Johnny Bible, Shana Camarata, Debi Owings, Roxanne Shufran, Sabina Kassymzhanova-Mirik, and Lana Castleberry

General Introduction

Prior to the wheat-growing season in 2002, we contacted five growers in order to locate five suitable dryland winter wheat and alternative crop fields in the Texas Panhandle. Five farmers agreed to conduct the AWPM study in their fields. Two fields are situated south of the Canadian river, in Deaf Smith and Swisher Counties. The three remaining fields are located north of the Canadian river, in Moore, Hutchinson, and Ochiltree Counties (Figure 1 and Table 1).

After locating the five AWPM fields, soil maps of the fields were obtained from county soil survey maps. Four 100x100 ft benchmarks were established based on changes in soil type and slope in each field. These benchmarks were selected in order to represent the major soil conditions and other possible variations in the fields. Soil fertility and moisture samplings were taken within each of the four benchmark areas in the fields.

Coordinates from the corners of the benchmarks and the fields were taken with a pocket PC and GPS receiver using the SiteMate program. The wheat and sorghum fields were divided into 25 and 10 equally-sized quadrats using 5x5 and 2x5 grid patterns, respectively. Sampling points were located in the center of the quadrats using GPS in both sorghum and wheat fields. Each sampling point was marked by a flag to exactly locate the sampling points at subsequent sampling dates. Mini weather stations were placed in all fields to record temperature and rainfall. Recording time interval was set to 15 minutes. Volunteer wheat, associated insects, and weed surveys in wheat, sorghum, and adjacent fields were conducted in each field 0-14 days before planting and after harvest. Wheat sampling for aphids, predators, parasitoids, and weeds started and continued biweekly after wheat came up as long as the weather conditions permitted. Data collection in the sorghum fields began in mid-July.

Throughout this report we present maximum and total numbers of individual insects and weeds by adding field, berlese, and sweepnet counts for each sampling date. Maximum number is the highest number of species found at one of sampling points and total is number of individual species found at all study plots. This permits to gain general information on the situation in the fields throughout the growing season.

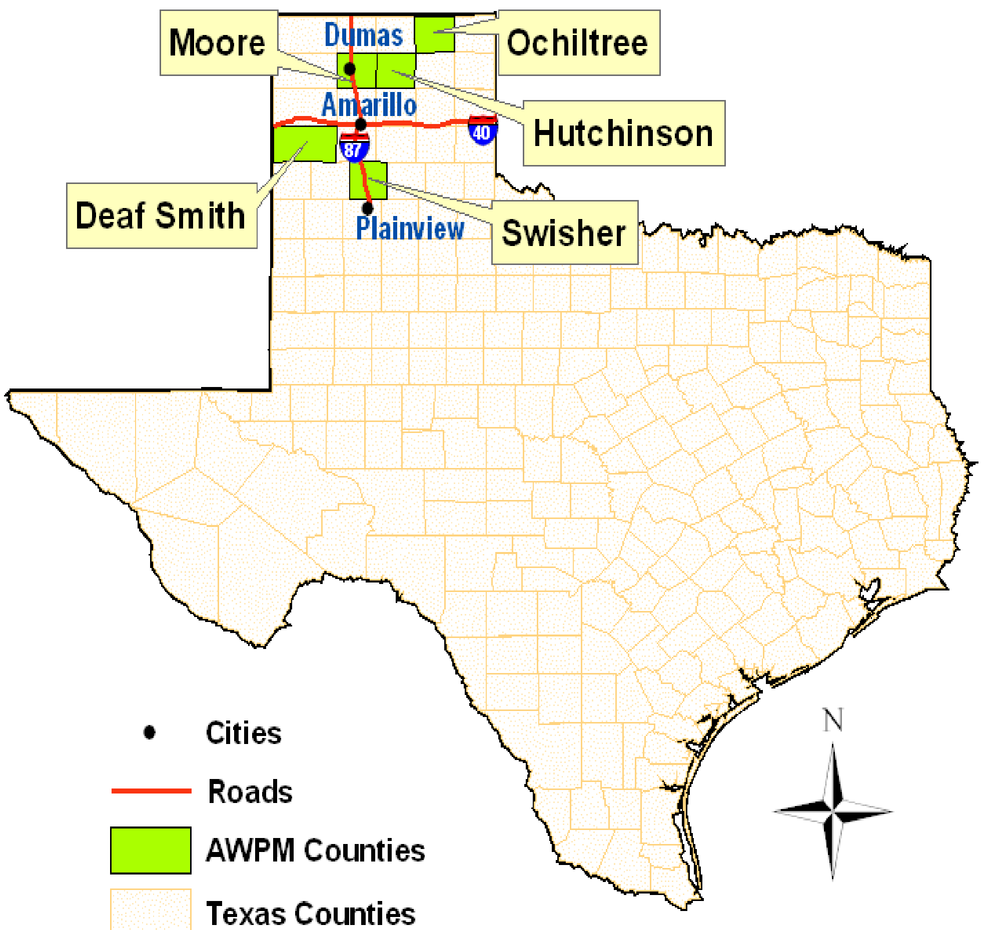


Figure 1: The locations of the AWPM counties where demonstration sites are located.

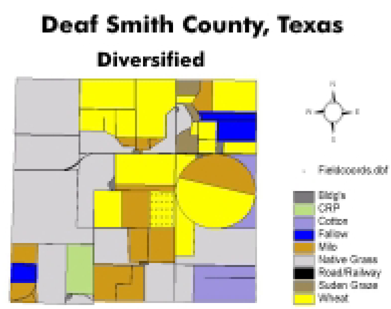
Although we hesitate to make blanket statements regarding this first year's results, it should be noted that the Texas Panhandle experienced sever drought and unusually high temperatures in 2002-2003. This is a continuation of a drought situation that seems to be continuing in 2003-2004. Although some fields received moisture during the year, these events were sporadic and rainfall was usually followed by long period of dry weather. We believe that this needs to be taken into account, and that this severe drought most likely had a significant impact on the data we collected. Hopefully data collected in subsequent years will all a better evaluation of the impact of the AWPM program if climatic conditions return somewhat to normal. We believe that extrapolations of this year's results are to be made with caution.

Table 1: Specific location, cooperator, crop practice, sampled crop and area of the AWPM fields.

County	Section	Block	Crop Rotation	Area Owned by Cooperator (ac)	AWPM Field (ac)	Crop Practice	Wheat Sampled in 02 & 03 (ac)	Sorghum Sampled in 03 (ac)	Wheat being Sampled in 03 (ac)
Deaf Smith	2	7	Diversified	4500	192	w-s-w	102	89	129
Hutchinson	20	M16	Diversified	4480	282	w-s-w	109	173	
Moore	389	44	Simple	3630	319	w-f-w			
Ochiltree	930	43	Simple	640	325	w-f-w	152		173
Swisher	90	M8	Simple	5000	162	con w			162

w- wheat, s – sorghum, f – fallow, con w – continues wheat

Deaf Smith County Wheat and Sorghum Fields



Deaf Smith County is in the western part of the Panhandle of Texas The County consists of 964,480 acres or about 1,500 square miles. It is rectangular and about 50 miles long and 30 miles wide. Elevations range from about 4,450 feet on the western edge of the county to about 3,650 feet along Tierra Blanca Creek. The city of Hereford is the largest city in the county. Wheat and grain sorghum are the main crops. Most of the northwestern part of the county consists of ranches.

The climate of Deaf Smith County is semiarid. During periods of drought, dryland crops produced little or no yield. These droughts are followed by years when rainfall is sufficient for favorable yields. The average annual rainfall is about 18.04 inches. The average annual temperature is 57.2°F. The soil series in the AWPM field in Deaf Smith County are Drake (DrD), Olton (OcB), Pullman (PmA and PmB), and Zita (ZcB). The point coordinates of the southeast corner of the AWPM fields are -102.257 (longitude) and 35.089 (latitude) with an elevation of about 3,806.4 feet.

This field, total area of 320.53 acres, was divided into three adjacent areas. In 2002, winter wheat was planted in 102 acres and sampled during that growing season. One hundred and eight bags of TAM 110 wheat seeds were delivered to the cooperator prior to wheat planting in 2002. In the summer of 2003, sorghum was sampled in 89 acres. Winter wheat was planted in 129 acres and is being sampled in the fall of 2003. Eighty bags of TAM 110 wheat seed were delivered to the owner before wheat planting in 2003.

Field bindweed was found in the field. Johnsongrass, crested wheatgrass, jointed goatgrass, and brome were found at the field borders (Table 2). Table 2 contains sampling dates, wheat growth stages, and overall information about species found in this field. During the entire growing season, few greenbug, corn leaf aphid and birdcherry oat aphid were found. There was a high amount of Russian wheat aphid, nabid, spider, armyworm, and convergent ladybeetle in late April and May, 2003. Rice root aphid, brown wheat mite and seven spotted ladybeetle rarely occurred in this field.

Counts were taken in the sorghum field weekly during the entire growing season. Pigweed, field bindweed, and Johnsongrass were the common weeds in the sorghum field (Table 3). Corn leaf aphid was found during the entire growing season (Table 3). Density of corn leaf aphid reached the highest amount in August. Greenbug and fall armyworm were rarely found. Density of nabids, convergent ladybeetles, and orius was high during the early and mid-growing season while green lacewing was found mid season.

This field was closely monitored in 2002 and 2003 by taking imageries and aerial pictures using an Airborne Imaging Spectrometer for Application (AISA) with ground data collection (Figure 2). AISA mounted in a Cessna 172 three-passenger airplane was used to scan the surface. Spatial resolutions of the image collected over the research site ranged from 1x1 to 3x3 m and there were 50 bands ranging from 509 nm to 886 nm. Yield data were obtained from this field by providing a combine and support technician to the producer (Figure 3). Wheat was harvested using a John Deere 9500 combine and a GreenStar mapping system. Sorghum has not been harvested at the time this report is being written.

Table 2: Density dynamics of pests, predators, and weeds throughout the growing season in the Deaf Smith County wheat field in 2002 and 2003.

Sampling dates	Growth stages	Greenbugs		Corn leaf aphids		Birdcherry-oat aphids		Russian wheat aphids		Rice root aphids		Nabids		Spiders		Armyworms		Hippodamia convergens		Coccinella semptempunctata		Brown wheat mites		Field bindweeds	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
10.31.02	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.13.02	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.27.02	22	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3
12.09.02	22	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	4
01.13.03	23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
02.10.03	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
03.10.03	29	6	17	.	.	1	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
03.24.03	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
04.11.03	32	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	10	19
04.24.03	50	4	7	.	.	3	6	.	.	.	.	.	.	4	49	.	.	20	1	.	.	.	.	10	21
05.13.03	78	3	10	.	.	.	.	6	19	8	8	14	141	11	87	9	59	6	20	3	4	5	5	10	14
05.29.03	91	.	.	.	.	.	.	46	715	.	.	4	20	3	31	10	88	1	10	.	.	.	.	10	30
06.17.03	93	.	.	.	.	.	.	.	.	.	.	1	2	2	13	1	6	1	4	.	.	.	.	.	.
06.30.03		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	14

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

Table 3: Density dynamics of pests, predators, and weeds throughout the growing season in Deaf Smith County sorghum field in 2003.

Sampling Dates	Growth stages	Corn leaf aphids		Greenbugs		Nabids		Spiders		Hippodamia convergens		Coccinella semptempunctata		Coccinella larvae		Scymnus loweii		Green lacewings		Brown lacewings		Lacewing larvae		Orius		Fall armyworms		Johnsongrasses		Field bindweeds		Pigweeds	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
07.15.03	2	16	16	.	.	3	15	1	1	4	4	.	.	.	.	1	1	.	.	.	.	.	.	19	71	.	.	.	.	.	.	.	.
07.22.03	2	142	376	.	.	2	6	1	1	8	25	.	.	.	.	1	1	.	.	.	.	.	.	10	29	.	.	.	.	.	.	.	.
07.28.03	3	675	2337	.	.	1	1	.	.	4	16	.	.	.	.	2	2	.	.	.	.	.	.	33	61	.	.	.	.	.	.	.	.
08.06.03	4	415	1996	.	.	2	3	1	1	4	19	1	1	2	3	.	.	.	.	.	.	.	.	5	19	.	.	.	.	.	.	.	.
08.13.03	4	260	1533	.	.	3	9	1	1	8	42	.	.	1	1	3	6	2	2	1	1	1	1	1	1	.	.	10	15	.	.	1	1
08.18.03	5	67	320	.	.	1	1	1	1	5	16	.	.	1	1	.	.	1	1	.	.	.	.	1	1	.	.	10	33	.	.	.	.
08.25.03	5	42	139	1	1	1	2	.	.	6	27	.	.	1	1	.	.	5	8	.	.	.	.	1	1	.	.	10	34	.	.	.	.
09.03.03	6	182	502	4	10	1	1	.	.	4	18	.	.	1	1	1	1	4	15	.	.	1	1	.	.	.	.	10	33	.	.	10	12
09.10.03	6	47	165	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	1	.	.	.	.	10	37	.	.	10	11
09.17.03	6	105	268	.	.	.	.	.	.	2	3	.	.	.	.	.	.	1	1	.	.	1	1	.	.	.	.	10	26	.	.	3	5
09.24.03	7	120	298	.	.	.	.	.	.	2	3	.	.	.	.	1	1	5	7	.	.	1	1	.	.	1	3	10	23	10	10	10	11
10.01.03	7	173	483	.	.	.	.	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	10	27	.	.	1	1
10.07.03	8	120	458	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	10	50	.	.	10	14
10.14.03	8	46	277	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	10	50	.	.	.	.
10.20.03	9	117	293	.	.	.	.	.	.	2	2	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	10	37	.	.	.	.
10.27.03	9	150	296	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	46	.	.	.	.
11.03.03	9	105	436	64	77	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	40	.	.	.	.
11.11.03	9	127	379	14	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	1	1	.	.	.	.	.	.	.	.

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

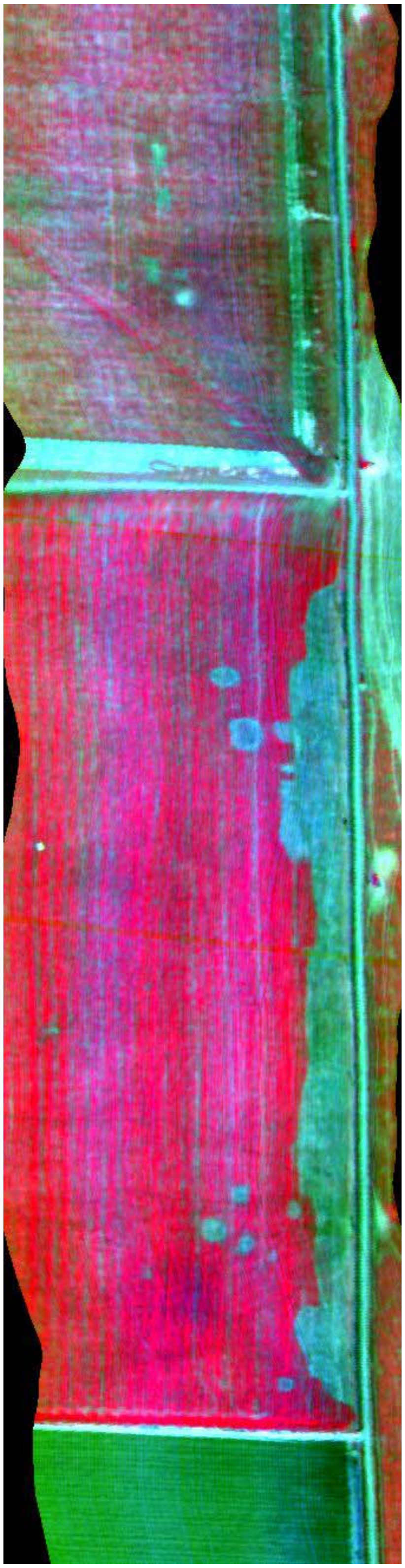


Figure 2: False color composite image (left) and aerial picture (right) of the Deaf Smith County wheat field.

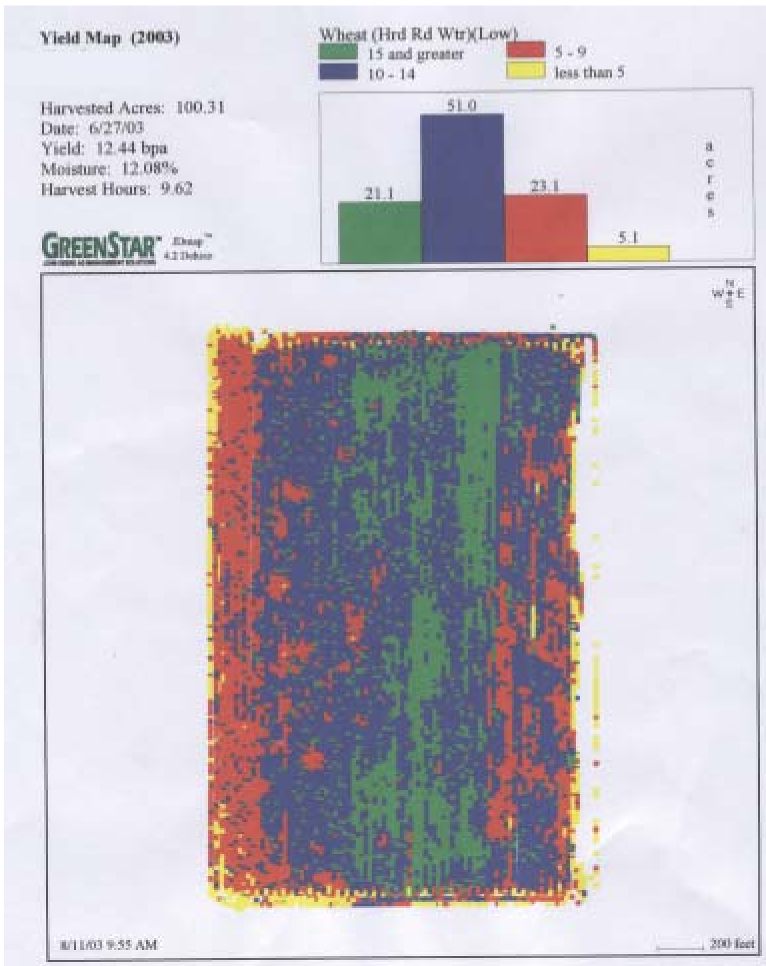
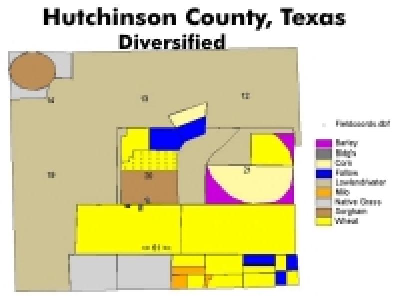


Figure 3: Yield map of the Deaf Smith County wheat field.

Hutchinson County Wheat and Sorghum Fields



Hutchinson County is located in north-central portion of the Texas Panhandle. It covers an area of about 583,040 acres or 911 square miles. The city of Stinnett is the county seat and Borger is the largest city in the county. About 74 percent of the Hutchinson County is used for range. Wheat is the main crop in Hutchinson County. The average annual rainfall is about 20.7 inches, and the average annual temperature is 58°F. The elevation above the sea level ranges from 2,750 to 3,400 feet. The soil series in AWPM field in Hutchinson County are Sherm (ShA) and Sunray (SuB) series.

The point coordinates of the southwest corner of the AWPM fields are -101.595 (longitude) and 35.967 (latitude) with an elevation of about 3,227.4 feet. This field, total area of 282.3 acres, was divided into two adjacent areas In 2002, winter wheat was planted in 109 acres and sampled during that growing season. Eighty nine bags of TAM 110 wheat seeds were delivered to the cooperator prior to the wheat planting in 2002. In the summer of 2003, sorghum was sampled in 173.4 acres. Sorghum fields were sampled weekly beginning in mid-July. However, aphid and beneficial insect population begin to decline in late August, 2003 in sorghum field. Thereafter counts were taken in the sorghum field biweekly. Yield data for both sorghum and wheat were obtained from the producer (Figure 4 and 5). A John Deere 9500 combine and a GreenStar mapping unit were used for harvesting and yield mapping, respectively.

Crested wheatgrass, Johnsongrass, and brome were found at the field borders. Brome was the only species found in wheat field (Table 4). Sampling dates, growth stages, overall density dynamics of the species found in this field were presented in Table 4. Few greenbug and birdcherry oat aphid were found in early March and continued being found in the field until harvest. Russian wheat aphid first appeared in early May and reached the highest amount just before harvest. There were high numbers of nabids, spiders, armyworms, and convergent ladybeetles during the late growing season. Mummies, carabids, *Scymnus loweii*, seven-spotted ladybeetles, green lacewings, and brown wheat mites were found once. In mid May, there were some green lacewing larvae.

Volunteer wheat, pigweed, crested wheatgrass, and Johnsongrass were found at the sorghum field borders. No weeds were found in the sorghum. The corn leaf aphid population fluctuated somewhat throughout the sorghum season. Density of corn leaf aphid was the highest on July 20. Aphid's natural enemies were high in late July and the first week of August. Green lacewings were found during the entire season.

Table 4: Density dynamics of pests, predators, and weeds throughout the growing season in the Hutchinson County wheat field in 2002 and 2003.

Sampling dates	Growth stages	Greenbugs		Birdcherry oat aphids		Russian wheat aphids		Nabids		Spiders		Hippodamia convergens		Coccinella semptempunctata		Coccinella maculata		Coccinellid larvae		Green lacewings		Lacewing larvae		Scymnus loweii		Black mummies		Armyworms		Carabids		Brown wheat mites		Bromus spp	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
11.07.02	24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.19.02	24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.03.02	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.12.02	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
01.27.03	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	13
02.12.03	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	20
03.07.03	34	2	4	1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	31
04.01.03	38	11	64	11	69	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	10	13
04.16.03	40	2	5	1	1	.	.	.	.	.	.	10	88	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	47
05.07.03	68	1	15	1	1	5	23	5	33	21	213	10	186	1	2	3	15	2	24	1	1	3	10	3	9	.	.	3	21	1	1	25	567	10	20
05.23.03	85	1	3	.	.	1	2	8	73	5	31	10	74	.	.	.	.	.	.	.	.	19	19	.	.	.	.	3	23	.	.	.	.	10	16
06.09.03	92	.	.	.	.	27	269	1	1	2	12	1	3	.	.	1	1	.	.	.	.	.	.	.	.	.	.	3	26	.	.	.	.	4	4

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

Table 5: Density dynamics of pests and predators throughout the growing season in Hutchinson County sorghum field in 2003.

Sampling dates	Growth stages	Corn leaf aphids		Nabids		Spiders		Hippodamia convergens		Coccinella semptempunctata		Coccinella maculata		Coccinellid larvae		Green lacewings		Brown lacewings		Lacewing larvae		Scymnus loweii		Orius	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
07.16.03	3	550	1379	6	13	1	2	18	80	4	5	3	9	7	10	1	2	1	1	2	3	2	5	2	7
07.21.03	4	565	2363	3	9	3	10	21	105	1	2	2	9	21	25	13	22	5	7	3	6	3	12	4	5
07.29.03	5	318	923	5	9	2	4	20	83	1	2	2	4	2	3	5	13	1	1	1	1	3	7	1	3
08.05.03	6	9	9	1	1	1	2	9	14	1	1	2	2	2	3	1	3	2	4	.	.	1	1	4	10
08.12.03	7	40	70	.	.	3	5	2	2	.	.	.	.	.	.	9	12	1	1	.	.	1	1	.	.
08.18.03	7	200	200	1	1	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	1	1	2	1	1
08.25.03	8	12	12	.	.	1	1	.	.	.	.	.	.	.	.	2	5	.	.	.	.	.	.	.	.
09.10.03	8	1	1	.	.	.	.	2	2	.	.	.	.	.	.	3	6	.	.	.	.	.	.	.	.
09.29.03	9	350	515	.	.	1	1	1	2	.	.	.	.	.	.	2	3	.	.	1	1	.	.	1	1

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

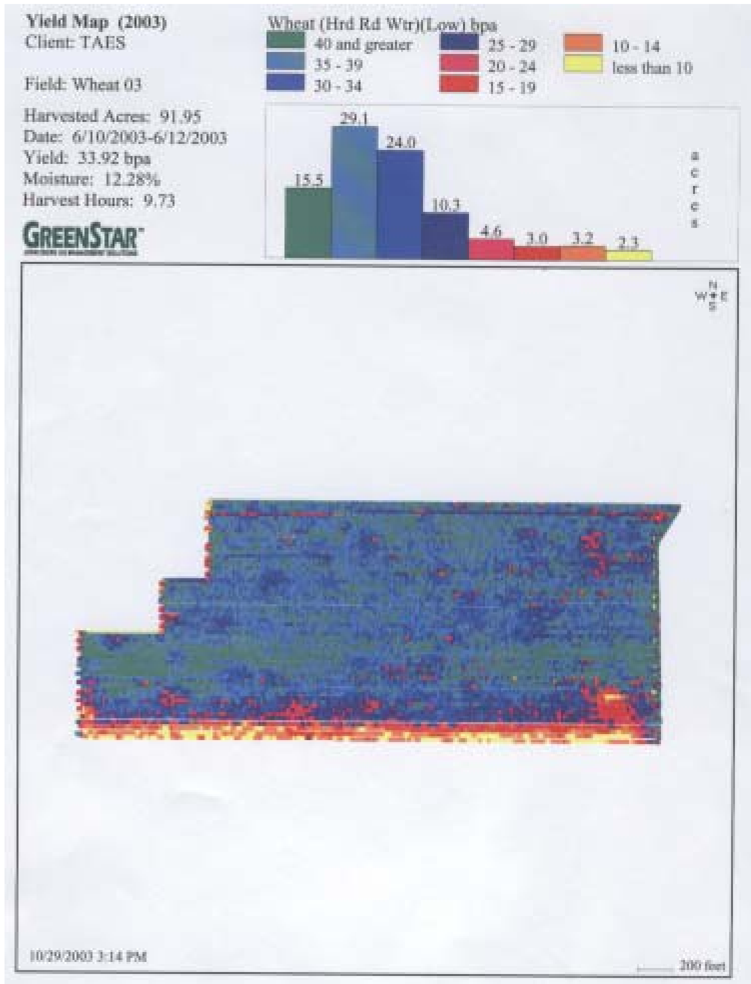


Figure 4: Yield map of the Hutchinson County wheat field.

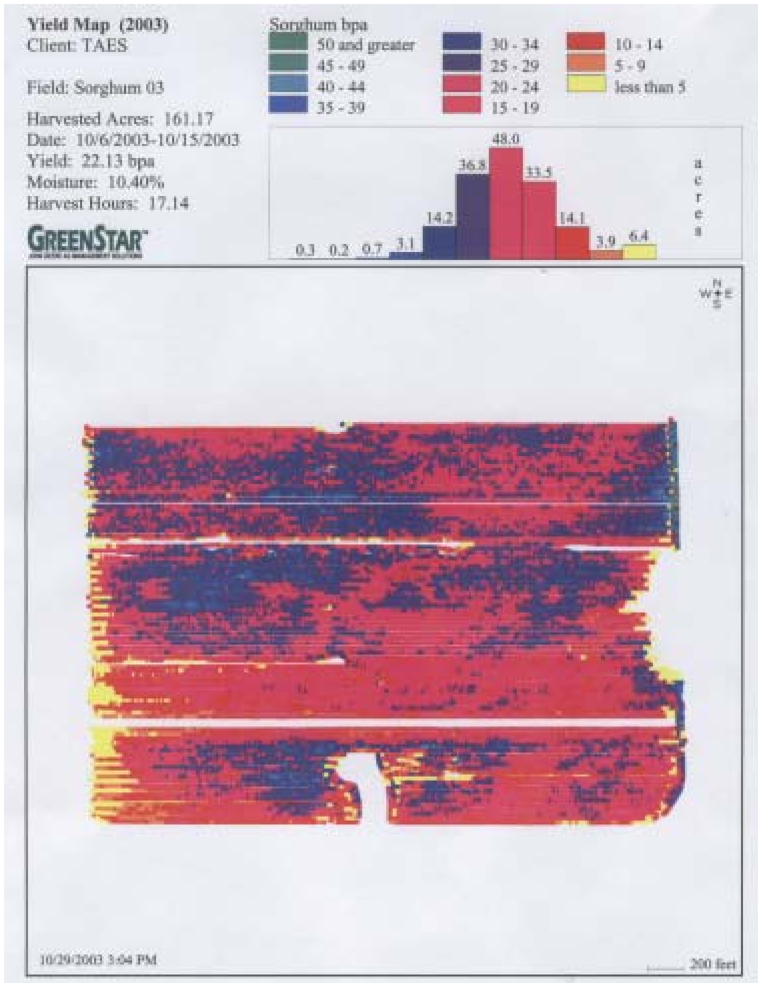
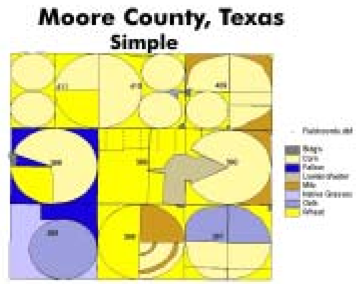


Figure 5: Yield map of the Hutchinson County sorghum field.

Moore County Wheat Field



Moore County is situated in north-central part of the Texas Panhandle (Figure). It covers an area of about 584,960 acres or 914 square miles. About 42 percent of the Moore County is used for crop production. The major crops are wheat and grain sorghum, lesser acreages of soybean, silage, corn and vegetable. Dumas is the largest city and county seat. Moore County has a dry, steppe climate. The average annual temperature is about 57.5°F. The average annual rainfall is 18.95 inches but varies from 8 to 27 inches. There are periods of drought in which dry-farmed crops produce little followed by years that are wet enough to produce profitable crops. The soil series in the AWPM field are Sherm (ShA) and Conlen (CoB) series.

The point coordinates of the northwest corner of the AWPM fields are -102.068 (longitude) and 35.967 (latitude) with an elevation of about 3,629.3 feet. In 2002, winter wheat was planted in the field and 189.6 acres was sampled (Figure). One hundred and nine bags of TAM 110 wheat seeds for the 189.6 acres were delivered to the owner of this field prior to the wheat planting in 2002. This field was grazed by cattle about one and a half months during the late winter and early spring in 2003. Yield data were obtained from this field by providing a combine and support technician to the grower (Figure 6). Wheat was harvest using a John Deere 9550 STS combine and a GreenStar mapping unit.

Weed species found at the field borders were Johnsongrass, brome, crested wheatgrass, and jointed goatgrass. Pigweed, barnyardgrass, and field bindweed were found in wheat field (Table 6).

Table 6 contains sampling dates, growth stages, and overall information about pests and their natural enemies. Like the Hutchinson County wheat field, few greenbug, birdcherry-oat aphid, and Russian wheat aphid were found during the entire season. Nabids, spiders, convergent ladybeetles, and armyworms were found starting from late April to harvest. English grain aphids, *C. maculata*, green lacewings, and brown lacewings were found in low numbers.

Table 6: Density dynamics of pests, predators, and weeds throughout the growing season in the Moore County wheat field in 2002 and 2003.

Sampling dates	Growth stages	Greenbugs		Birdcherry-oat aphids		Russian wheat aphids		English grain aphids		Nabids		Spiders		Hippodamia convergens		Coccinella maculata		Coccinellid larvae		Green lacewings		Brown lacewings		Lacewing larvae		Armyworms		Field bindweeds		Amaranthus spp		Barnyardgrasses	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
11.05.02	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	616	1	10	10	46
11.14.02	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	553	.	.	.	.
11.18.02	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	222	.	.	.	.
12.11.02	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
01.27.03	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
03.12.03	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
03.26.03	33	2	9	3	5	.	.	.	.	.	.	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	184	.	.	.	.
04.15.03	35	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	574	.	.	.	.
04.30.03	65	2	4	2	11	2	6	1	3	2	6	13	163	2	17	1	2	3	10	1	2	1	1	1	1	1	1	10	540	.	.	.	.
05.20.03	83	2	9	.	.	2	13	.	.	3	10	6	55	1	1	.	.	.	.	.	.	.	.	.	.	4	23	10	591	.	.	.	.
06.02.03	91	.	.	.	.	12	10	.	.	2	11	5	60	1	2	.	.	.	.	.	.	.	.	.	.	12	136	10	575	.	.	.	.
06.18.03	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	628	10	173	.	.

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

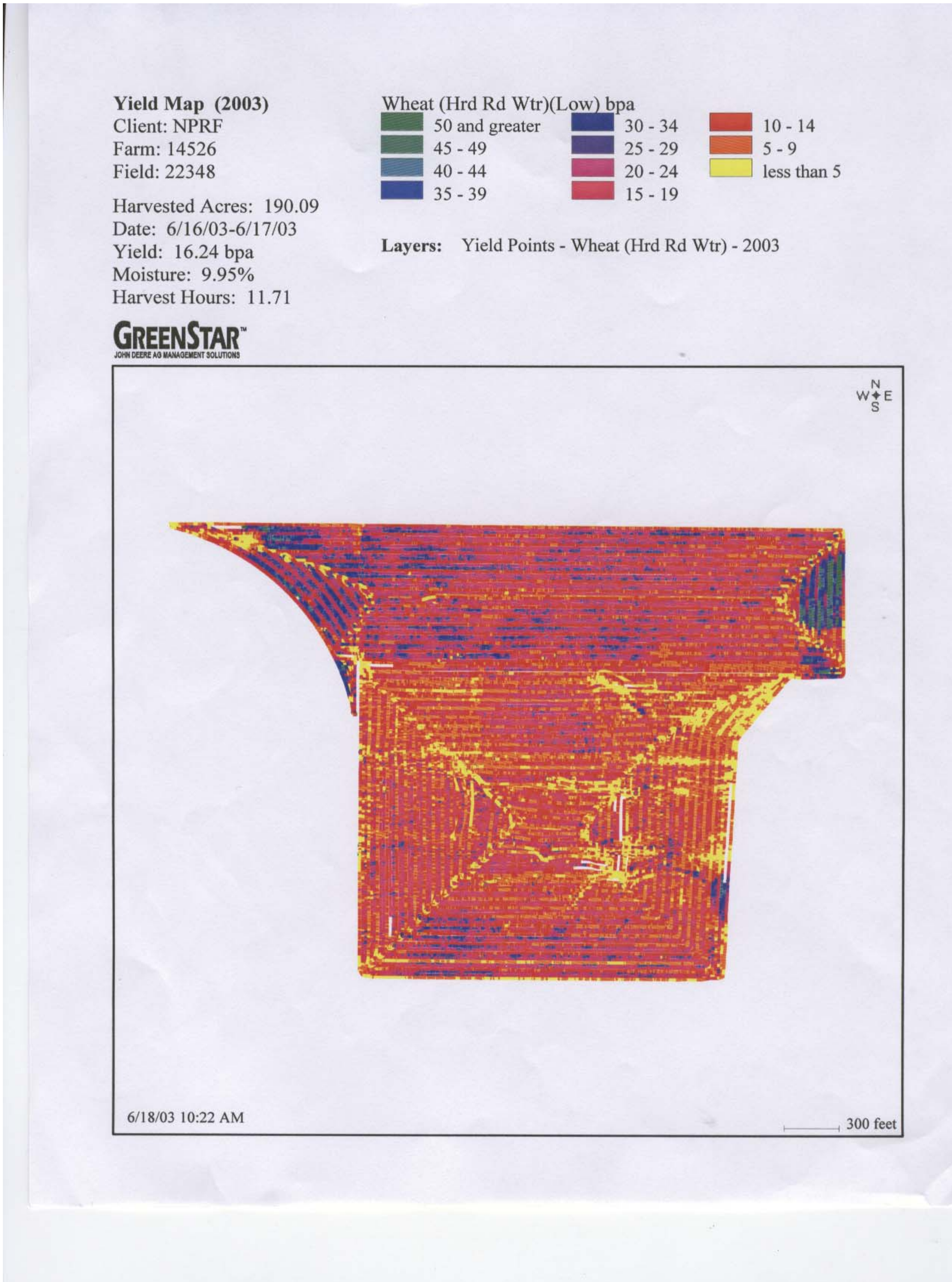
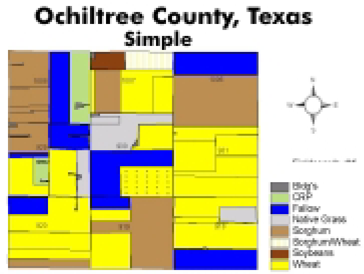


Figure 6: Yield map of the Moore County wheat field.

Ochiltree County Wheat Field



Ochiltree County is in the northwestern part of Texas, at the northern edge of the Texas Panhandle (Figure) . The county is about 30 miles square and has a total area of about 580,480 acres or about 907 square miles with an average elevation 2930 feet. Perryton is the county seat. About 70 percent of the county is cropland and the remaining 30 percent is rangeland. Most of the cultivated acreage is dryland. The major crops in this county are wheat and grain sorghum.

The climate of the county is sub-humid. The average annual rainfall is about 21.13 inches and the average annual temperature is about 57°F. The soil series in AWPM field in Ochiltree County are the Pullman (PmA and PmB), and Randall (Ra) series. The point coordinates of the southeast corner of the AWPM fields are -100.693 (longitude) and 36.348 (latitude) with an elevation of about 2,791.7 feet. This field, total area of 515 acres, was divided into four adjacent areas, two of which are subject to wheat – fallow - wheat rotation each year. Parts of the field are 152, 173, 100, and 90 acres, respectively. In 2002 and 2003, 152 acres of the field was sampled. One hundred seventy three acres are being sampled in the fall of 2003. This field is not subject to grazing by cattle. The cooperators harvested this field without notifying us and therefore no yield data were obtained.

Field bindweed and brome were found in the field (Table 7). Brome, crested wheatgrass, jointed goatgrass, and Johnsongrass were found at the field borders.

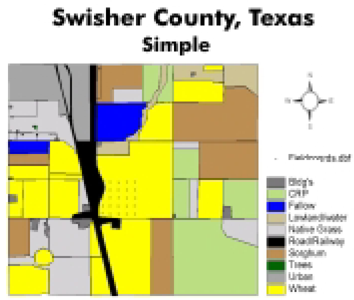
Sampling dates, growth stages, population dynamics of species found in this were given in Table 7. Greenbug and birdcherry oat aphid were found for the first time in late February, 2003, and stayed in the field during the rest of the season. There were high numbers of Russian wheat aphids, nabids, spiders, and convergent ladybeetles from late April to harvest. Seven-spotted ladybeetles, green lacewings, brown lacewings, *Scymnus loweii*, mummies, armyworms, carabids, and brown wheat mites were rarely found in this field.

Table 7: Density dynamics of pests, predators, and weeds throughout the growing season in the Ochiltree County wheat field in 2002 and 2003.

Sampling dates	Growth stages	Greenbugs		Birdherry oat aphids		Russian wheat aphids		Nabids		Spiders		Hippodamia convergens		Coccinella semptempunctata		Coccinellid larvae		Green lacewings		Brown lacewings		Scymnus loweii		Black mummies		Armyworms		Carabids		Brown wheat mites		Amaranthus spp		Bromus spp	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
11.08.02	20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.20.02	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.04.02	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.16.02	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2
01.28.03	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
02.21.03	30	2	3	7	7	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	3
03.13.03	30	.	.	1	1	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
04.07.03	32	14	61	17	126	.	.	.	.	.	.	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	4
04.17.03	32	1	2	3	8	.	.	.	.	.	.	5	11	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	1
05.12.03	75	1	7	4	11	2	3	4	12	8	58	6	39	1	1	1	1	.	.	1	1	1	1	.	.	.	.	1	3	4	9	.	.	1	1
05.28.03	87	1	1	1	1	2	12	6	56	7	63	7	58	.	.	.	.	2	9	.	.	.	.	.	.	4	33	.	.	.	.	.	.	.	.
06.12.03	92	.	.	17	78	54	386	6	26	3	23	7	35	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
07.01.03		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	13	.	.

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

Swisher County Wheat Field



Swisher County is in the south central part of the Texas Panhandle (Figure). The county has a total area of 573,440 acres or about 896 square miles. Tulia is the county seat. This county is a nearly level, playa-pocked, short-grass prairie. Elevation ranges from about 3,250 feet in the eastern part to 3,700 feet in the northwestern part. The climate of Swisher County is dry steppe. The average annual rainfall is about 17.24 inches and the average annual temperature is about 59.1°F.

Development of the county has depended on farming. About 80 percent of the county's land area is cultivated, and most of this is irrigated. The major crops are grain sorghum, wheat, cotton, and soybean. About 20 percent of the county is in native range that is grazed by cattle. The soil series in AWPM field in Swisher County are Pullman (PmA) series.

The point coordinates of the southwest corner of the AWPM fields are -101.838 (longitude) and 34.721 (latitude) with an elevation of about 3,506.9 feet. This field is 541 acres. Data for AWPM project were collected in 161.8 acres of the field. This field was grazed year round by cattle during the wheat-growing season in 2002 and 2003. The southwest corner of the field where sampling grids and points were located was grazed heavily in the spring of 2003. Therefore, no wheat was left to sample at 20 of the 25 sampling points. Data are being collected in this field for 2003 and 2004. Like the field in Deaf Smith County, this field was also closely monitored in 2002 and 2003 (Figure 7).

Common weed species found in this field were field bindweed and brome (Table 8). At the field borders, Johnsongarss, crested wheatgrass, brome, and jointed goatgrass were found.

Sampling dates, growth stages, population dynamics of species found in this field were given in Table 8. Greenbug and birdcherry-oat aphid were found in March, 2003, and they disappeared shortly. Thereafter some Russian wheat aphids were found in May. Nabids, spiders, mummies, and armyworms rarely occurred in this field. Convergent ladybeetles were found from late April to harvest.

Table 8: Density dynamics of pests, predators, and weeds throughout the growing season in the Swisher County wheat field in 2002 and 2003.

Sampling dates	Growth stages	Greenbugs		Birdcherry oat aphids		Russian wheat aphids		Corn leaf aphids		Nabids		Spiders		Hippodamia convergens		Coccinellid larvae		Mummies		Armyworm		Bromus spp		Field bindweeds		Amaranthus spp	
		M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
11.04.02	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	10	279	3	5
11.18.02	25	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	3	6	10	181	.	.
12.02.02	26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	13	10	126	.	.
12.17.02	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	8	10	59	.	.
01.22.03	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	19	.	.	.	.
03.11.03	29	1	3	10	38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	19	3	3	3	3
03.27.03	30	45	334	21	171	.	.	.	.	.	.	.	.	6	15	3	3	6	16	.	.	3	28	10	95	.	.
04.14.03	33	.	.	.	.	.	.	.	.	.	.	.	.	7	45	.	.	.	.	.	.	3	13	10	191	.	.
04.28.03	65	1	2	2	6	.	.	.	.	12	40	6	18	5	14	.	.	.	.	.	.	1	2	10	16	.	.
05.14.03	85	.	.	.	.	1	1	.	.	2	3	1	1	1	1	.	.	.	.	1	1	.	.	3	18	.	.
05.30.02	93	.	.	.	.	13	41	.	.	.	.	.	.	1	1	.	.	.	.	2	5	.	.	10	46	.	.
06.17.03	95	.	.	.	.	.	.	.	.	1	2	2	4	.	.	.	.	.	.	.	.	.	.	10	80	.	.
06.25.03		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	203

M - Maximum number of individual insects, mites, and weeds at one of the sampling points.
T - Total number of individual insects, mites, and weeds for the entire field.
. – Species were not found.

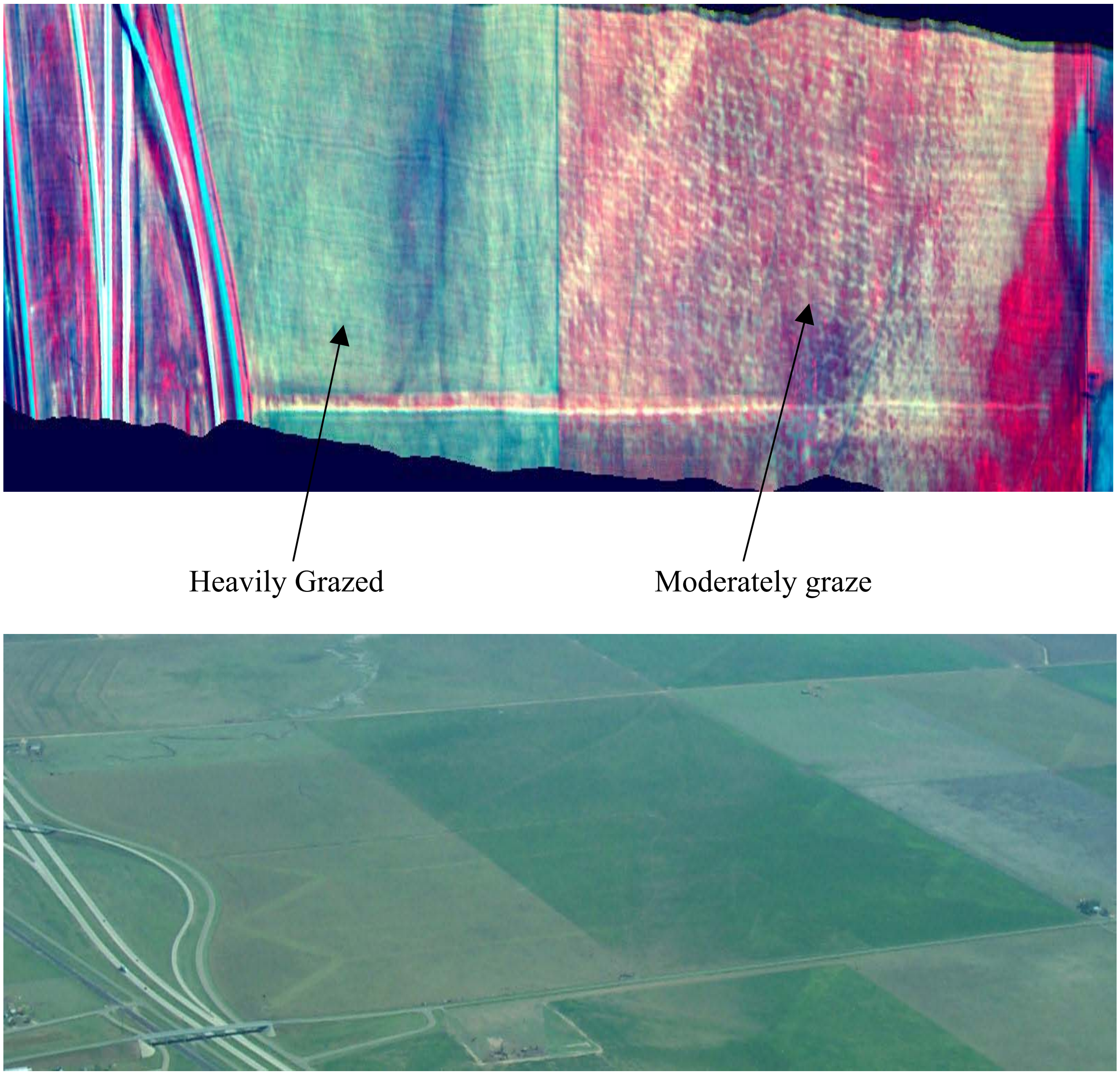
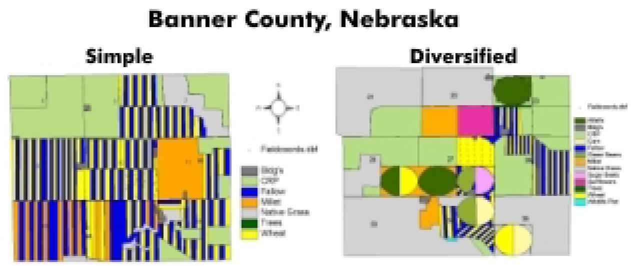


Figure 7: False color composite image (top) and aerial picture of the Swisher County wheat field.

c. Nebraska/Wyoming Demonstration Sites

Phase II, Year 1 (2002-2003)
Prepared by Gary Hein, Drew Lyon, John Thomas, and Rob Higgins

Nebraska Sites



The paired locations of sites in Nebraska were located in western Banner County. The areas surrounding both fields have a large amount of rangeland grass or CRP grassland. Sampling of these locations began in the fall of 2002 and continued until the end of the season in 2003. Overall the aphid populations were low until late in the season.

Diversified rotation: The grower of the diversified field is strongly committed to making an intensive rotation work as he has been doing for several years. His targeted rotation is winter wheat / sunflowers / proso millet / spring crop. The spring crop is still the unknown in his rotation as he has not arrived at a good option for his system. He would like to include barley but because of potential Russian wheat aphid problems he has not consistently adopted this. A resistant barley variety would fit into his system well as he raises cattle and could use the barely for feed. His second option for this fourth year is a second year of proso millet. This option got him into trouble in 2002 as his millet was severely drought stressed until late in the season when it began to grow and mature very late. He was not able to get his millet off until well into October, and he did not plant his wheat until October 10-11. This is a full month after the recommended planting date for the area. The wheat was just barely through the ground when it went dormant with the cool weather. In the spring the wheat did resume growth but through the winter there had been a tremendous infestation of kangaroo rats that had moved into the field and destroyed a significant amount of wheat. Close to 10% of the wheat had been torn up or consumed by these rodents.

The wheat was growing well through the spring, but it was significantly delayed compared to the wheat in the surrounding areas. Because of the much delayed planting, no aphids were seen it the field until May 21 when a 7% infestation of RWA was observed. The infestation quickly increased to about 35% on June 5. Because this field had been planted to Halt, a RWA resistant variety, the extent of the infestation and the rapid buildup was very surprising. At this point we had heard that Colorado State had already identified the same problem in resistant varieties in Colorado. Therefore, we assumed that we also were seeing the presence of this new RWA biotype. Infestations increased until July 9 when 600 RWA per row foot were found in the Berlese samples. The seriousness of the infestation was largely due to the lateness of this wheat field because the surrounding fields planted to susceptible varieties that were all at more mature stages showed no significant sign of serious RWA infestation. Dry and hot conditions during late June and early July had a negative effect on this field and the field averaged 18 bushels per acre (harvested July 22). Clearly, this yield had been impacted by late planting, rodents, RWA and late season drought.

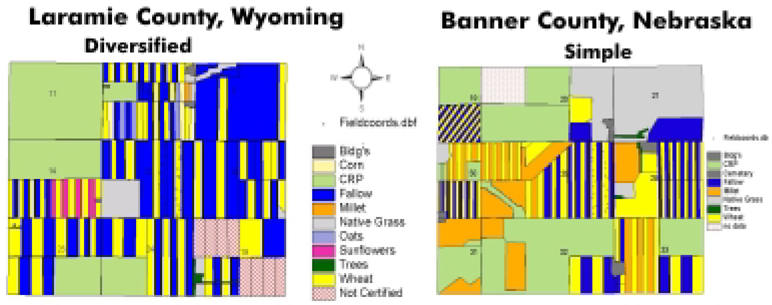
Greenbug populations in the field were first found on June 5 with only a 1% infestation level and 25 per row foot. Greenbug populations did not increase from this point. Because of the high aphid populations, coccinellid populations were very high in this field. Coccinellid populations began to increase on June 18 about a month after the aphids showed up and increased to a high of 14 adults and 14 larvae per 25 sweeps or 1.1 coccinellids per sweep.

Very few grass weeds were observed in the winter wheat field or the adjacent summer crop fields. In the spring there were a few broadleaf weeds in the winter wheat field, but these were controlled with herbicides. Insect pests were not a big problem in the alternate crops, but pheromone sampling for the sunflower head moth indicated a significant populations and the field was treated with insecticide. Control of the head moth was good, but later infestations may have resulted in a low-moderate infection rate of Rhizopus head rot in the sunflowers. No additional pest problems were noted in this rotational system.

Wheat / fallow rotation: The wheat / fallow grower has farmed in the winter wheat / fallow system for many years. He planted his winter wheat just a little late due to area rains (Sept. 13). A good stand was obtained in the fall and the crop went into the winter in very nice shape with no aphid infestations. Sampling in the spring indicated only a slight RWA infestation of 1% infested tillers. This infestation did not increase through the spring as it remained 1% until heading when it dropped. This drop is likely due to the difficulties of locating aphids within the wheat heads. Berlese samples indicated that aphid populations did increase through the heading period until we saw about 42 aphids per row foot on July 2. This field was harvested on July 13 and yielded an average of 40 bushels per acre. The only significant impact on yield during the season appeared to be moderate to severe drought stress occurring during the late season period.

No other insect pest or disease problems occurred in the field. As was expected for such low aphid infestation, coccinellid populations were low as well peaking at only 6 adults and larvae per 25 sweeps on July 2 just before full maturity. Weeds were not a problem in the fall in the growing wheat. However, the adjacent fallow fields had moderate to heavy infestations of volunteer wheat prior to wheat planting. Light to moderate infestations of feral rye and downy brome developed in the winter wheat fields over the winter and into the spring. No significant disease impacts were seen in the wheat.

Wyoming/Nebraska Sites



The two sites for this pair are located in Wyoming and just across the border in Nebraska. Growing conditions for this pair of locations was much better than most of the surrounding region. These areas saw considerably more rainfall both just before planting and through the season. Planting at both locations was delayed by rainy and wet conditions, but wheat establishment was excellent at both locations.

Diversified Rotation: The grower of the diversified-rotation field shown at left suffered very serious drought losses in 2002, averaging less than 5 bushels of wheat per acre on his whole operation. As a result of the extremely dry conditions in 2002, he did not plant sunflowers as he had anticipated. Beginning in early August the rains began and he saw over 10 inches of rainfall in the next 6 weeks (normal annual precipitation ca. 13 inches). He planted somewhat late for the area on Sept. 18-19, but due to the adequate moisture, establishment and stands were good. These fields were planted to the RWA resistant varieties Halt and Prowers. No RWA infestations were seen in these fields until May 30 when a 1% infestation levels was found. These aphid levels did not increase and very low coccinellid populations were seen as well (0.45 /25 sweeps).

Very few grass weeds were observed in the winter wheat field. In the spring there were a few broadleaf weeds in the winter wheat field, but these were controlled with herbicides. No additional pest problems were observed in these fields through the course of the season, but in June a significant hail damaged the crop. After re-growth from the hail damage, the wheat was harvested on August 4-6 and it yielded 27.5 bushels. This is a good yield considering the impact of the hail that was seen.

This grower again did not plant sunflowers in 2003 and has changed his ideas on his rotations because of the serious dry conditions he has seen the last years. Since wheat harvest, we have identified another diversified rotational grower in the area and have initiated our fall 2003 sampling on this growers land.

Wheat/fallow rotation: This location is surrounded by a good deal of perennial grass including some CRP in the area. The section where the fields are located is cut up by grassed waterway and drainage. The grower was delayed slightly in planting in the fall of

2002 because of rain. However, more than adequate rainfall during this period resulted in very good establishment and stand of wheat after planting on Sept 3-4 (cv. Ogallala). RWA populations were not observed in the fall but a 1% infestation was observed on April 29. This aphid population did not increase over the spring and only reached a 3% infestation on June 26. The maximum density of RWA was seen on June 26 also at 100 RWA per row foot. Maximum coccinellid levels were seen on June 11 at 6/25 sweeps. Very low numbers of Greenbugs were also seen (<1% infestation).

Weeds were not a problem in the fall in the growing wheat. However, the adjacent fallow fields had moderate to heavy infestations of volunteer wheat prior to wheat planting. Light to moderate infestations of feral rye and downy brome developed in the winter wheat fields over the winter and into the spring. No significant disease impacts were seen in the wheat. The fields were harvested on July 20 and the wheat yielded 41.6 bushels per acre, a very good yield for this area.

d. Oklahoma Demonstration Sites

Phase II, Year 1 (2002-2003)
Prepared by Kris Giles and Vasile Catana

During the 2002-2003 winter wheat growing season in Oklahoma, a total of six demonstration sites were evaluated by OSU and USDA-ARS scientists for aphid, natural enemy, and weed abundance. A pair of diverse (wheat in rotation with another crop) and simple (continuous wheat) sites were identified in Jackson, Alfalfa, and Kay/Noble county (Fig. 1). Demonstration sites in these counties were chosen to represent the variability in environmental conditions that can occur within Zone-2 (continuous cropping) of the overall areawide program.

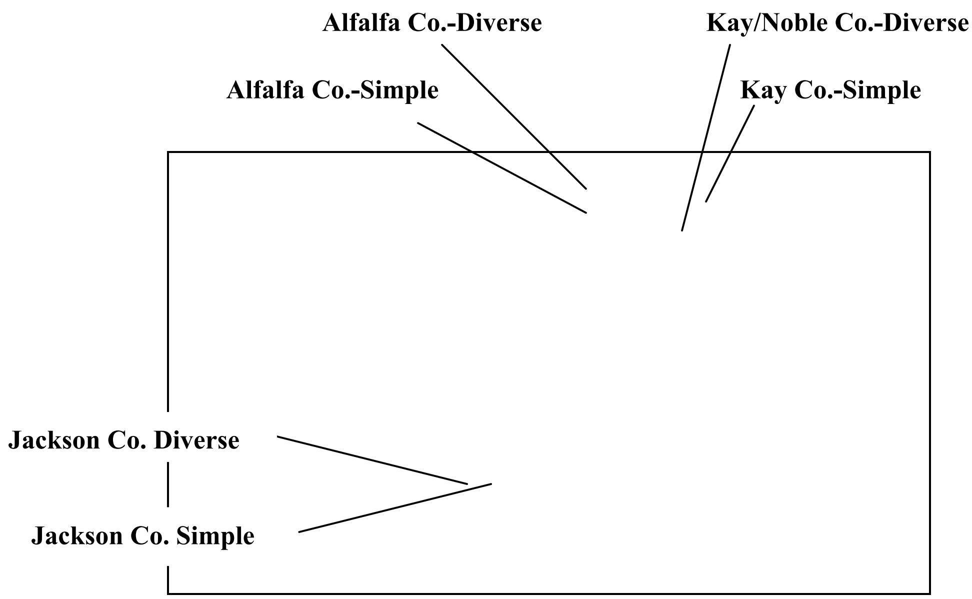


Figure 1. Location of demonstration sites in Oklahoma

Site Description

Jackson County. The diverse site was chosen primarily because the grower rotates winter wheat with a variety of different crops including alfalfa, sorghum, corn, peanuts, and cotton. Following the 2002-2003 winter wheat crop, cotton was rotated into production (Fig. 2 A). This field was embedded within a diverse landscape that included a significant area of lowland water. The simple (continuous wheat) site (Fig. 2 B) was embedded primarily within a grass habitat (Wheat and other grasses).

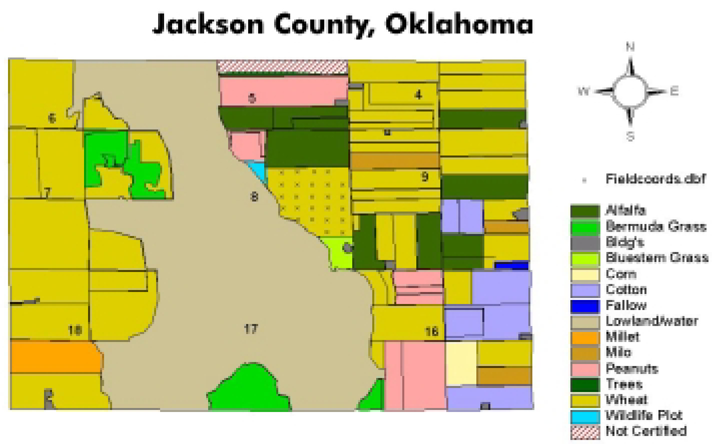


Fig. 2 A. Jackson Co. Diverse

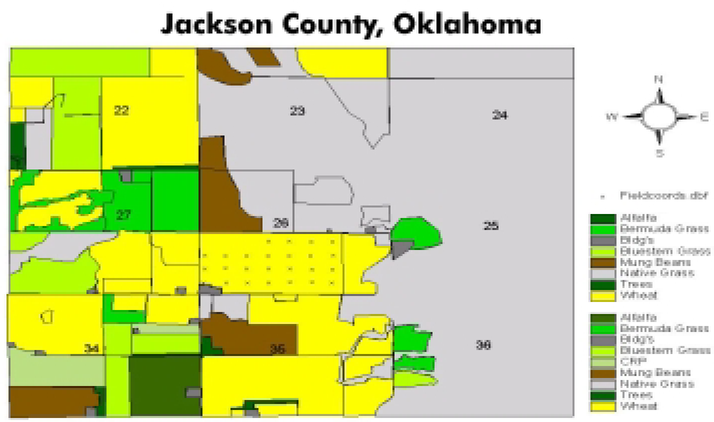


Fig. 2 B. Jackson Co. Simple

Alfalfa County. The diverse site was chosen primarily because the grower rotates winter wheat with sorghum. Following the 2002-2003 winter wheat crop, sorghum was rotated into production (Fig. 2 C). This field was embedded within a landscape mostly of wheat, but with a small amount of alfalfa and sorghum. The simple (continuous wheat) site (Fig. 2 D) was embedded primarily within a grass habitat (Wheat and other grasses) with a small amount of alfalfa production.

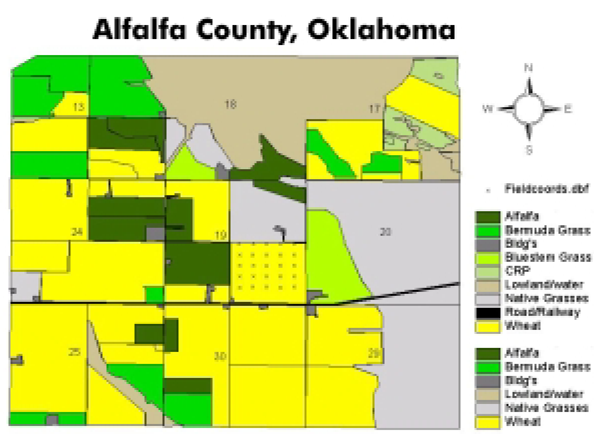


Fig. 2 C. Alfalfa Co. Diverse

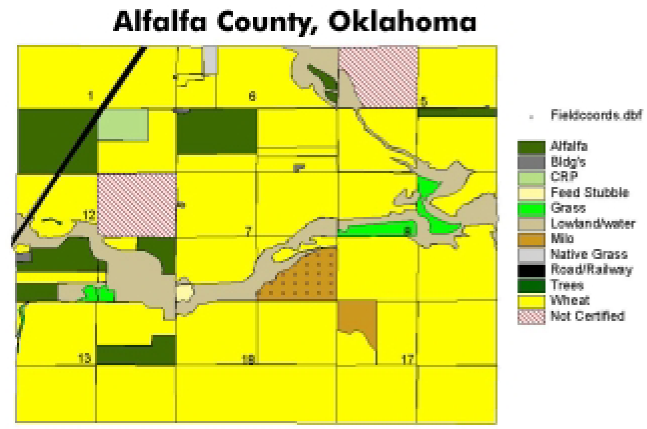


Fig. 2 D. Alfalfa Co. Simple

Kay/Noble Counties. The diverse site was chosen primarily because the grower rotates winter wheat with sorghum. Following the 2002-2003 winter wheat crop, sorghum was rotated into production (Fig. 2 E). This field was embedded within a landscape mostly of wheat, but with a significant area devoted to soybean production and small amount of alfalfa. The simple (continuous wheat) site (Fig. 2 F) was embedded primarily within a grass habitat (Wheat and other grasses) with a small amount of alfalfa production.

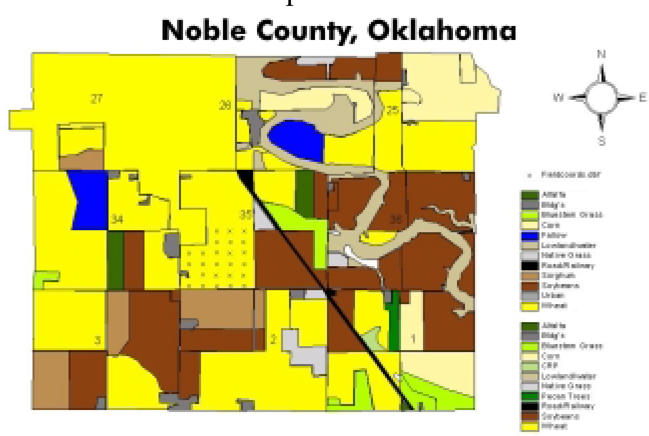


Fig. 2 E. Kay Co. Diverse

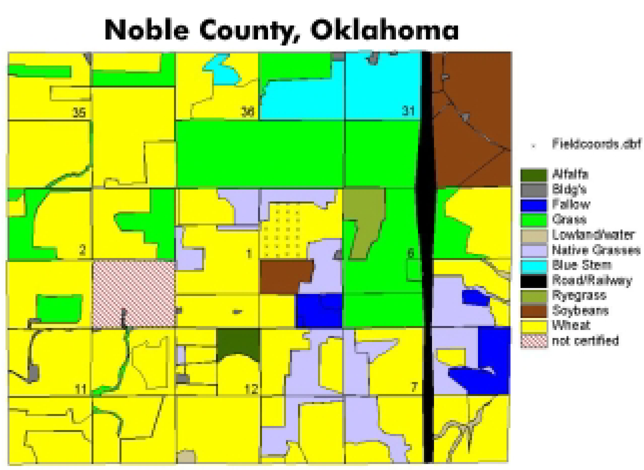


Fig. 2 F. Kay/Noble Co. Simple

Sampling

Developed protocols for sampling arthropods and weeds in wheat and alternative crops were followed (See appendix for details). Briefly for arthropods in wheat, we sampled for aphids (Tiller and Burlese), predators (Visual and Sweep), and parasitoids (Tiller / emergence tubes) at 25 grided locations throughout each field multiple times during the growing season.

Results

Arthropod abundance in wheat

Aphids and parasitoids from tiller samples. In general, greenbugs were found at extremely low levels in all of the fields evaluated (Fig. 3). Parasitism (*Lysiphlebus testaceipes*) of greenbugs at each site was consistently present throughout the growing season, which clearly limited numbers. Significant numbers of other aphids (primarily Bird-cherry-oat aphids - BCOA) were present at a few of the locations, but showed no noticeable trends between diverse and simple demonstration sites. BCOA did however supply significant hosts for parasitoids and predators.

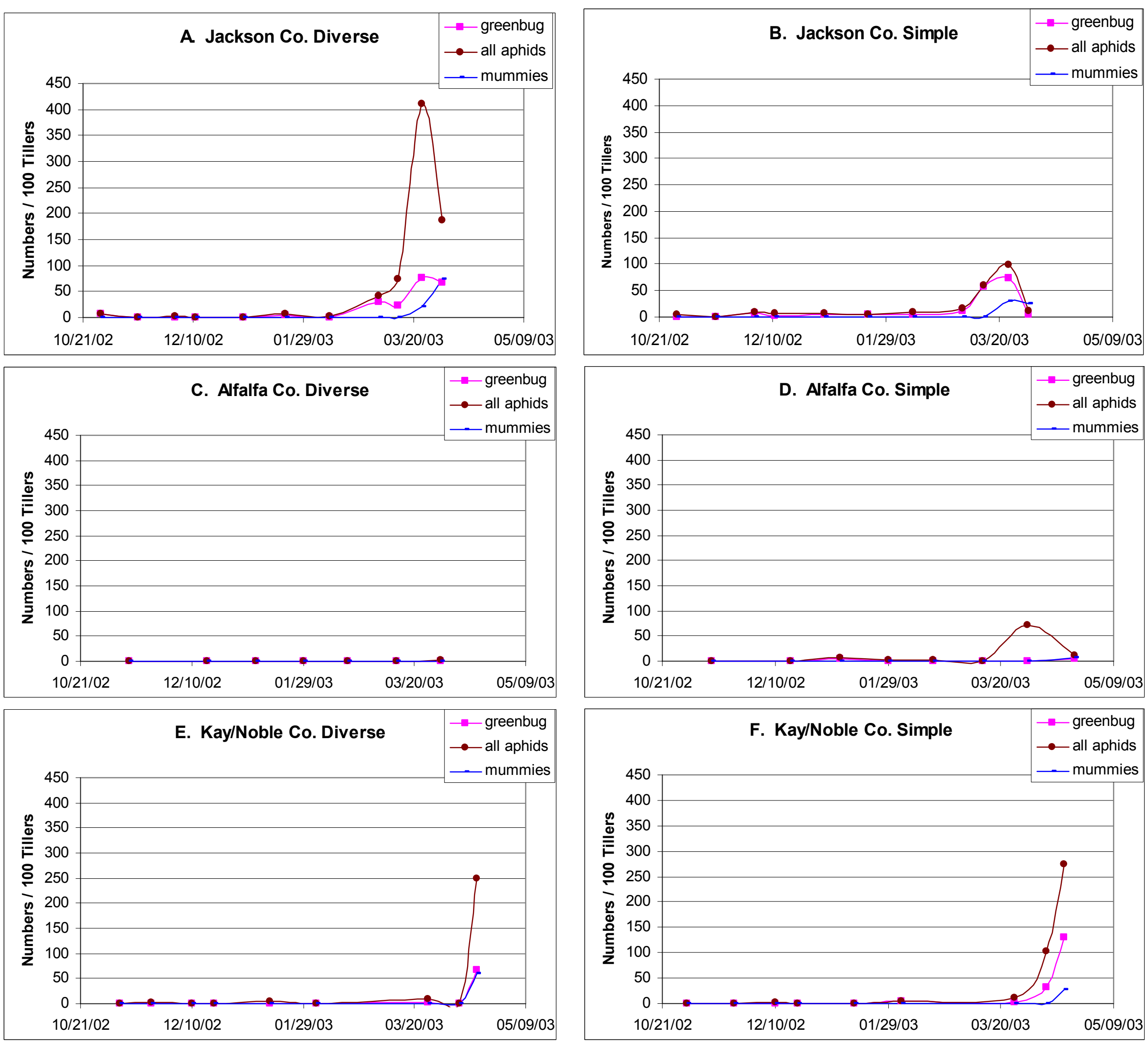


Figure 3. Greenbugs, all aphids combined, and mummies (parasitized aphids) in Winter Wheat at Oklahoma Demonstration Sites.

Aphids from burlese samples. Greenbugs were found at extremely low levels in all of the fields evaluated (Fig. 4). No noticeable trends in aphid abundance between diverse and simple demonstration sites were observed other than the consistently higher numbers at the beginning of the field season at diverse sites. When aphids were abundant, BCOA and Cornleaf-aphids were the primary aphids found. These aphids likely supplied significant hosts for parasitoids (Fig. 3) and predators (Figs. 5 and 6).

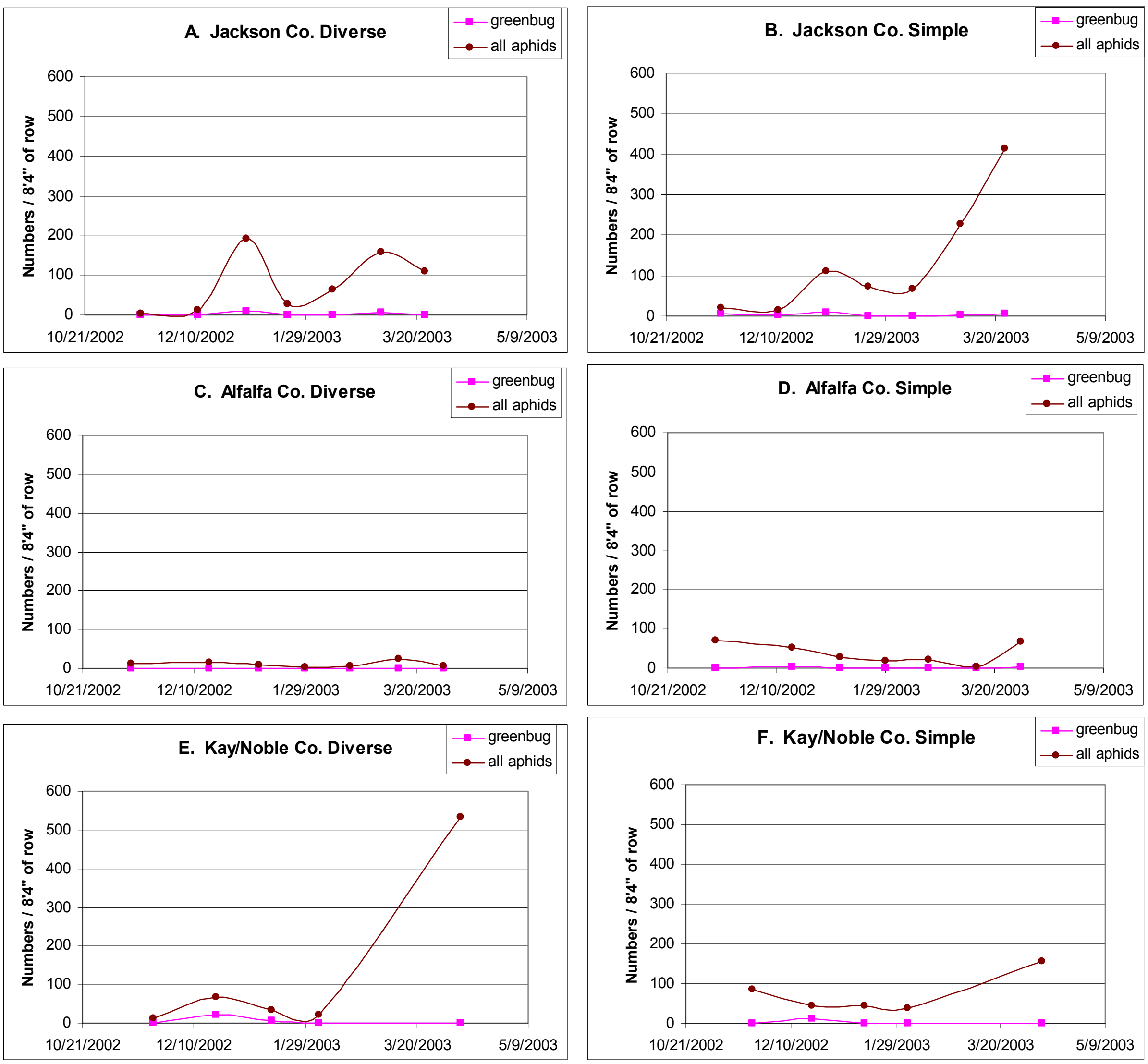


Figure 4. Greenbugs and all aphids in Burlese samples from Winter Wheat at Oklahoma Demonstration Sites. Numbers were summed over twenty five 4”- burlese samples.

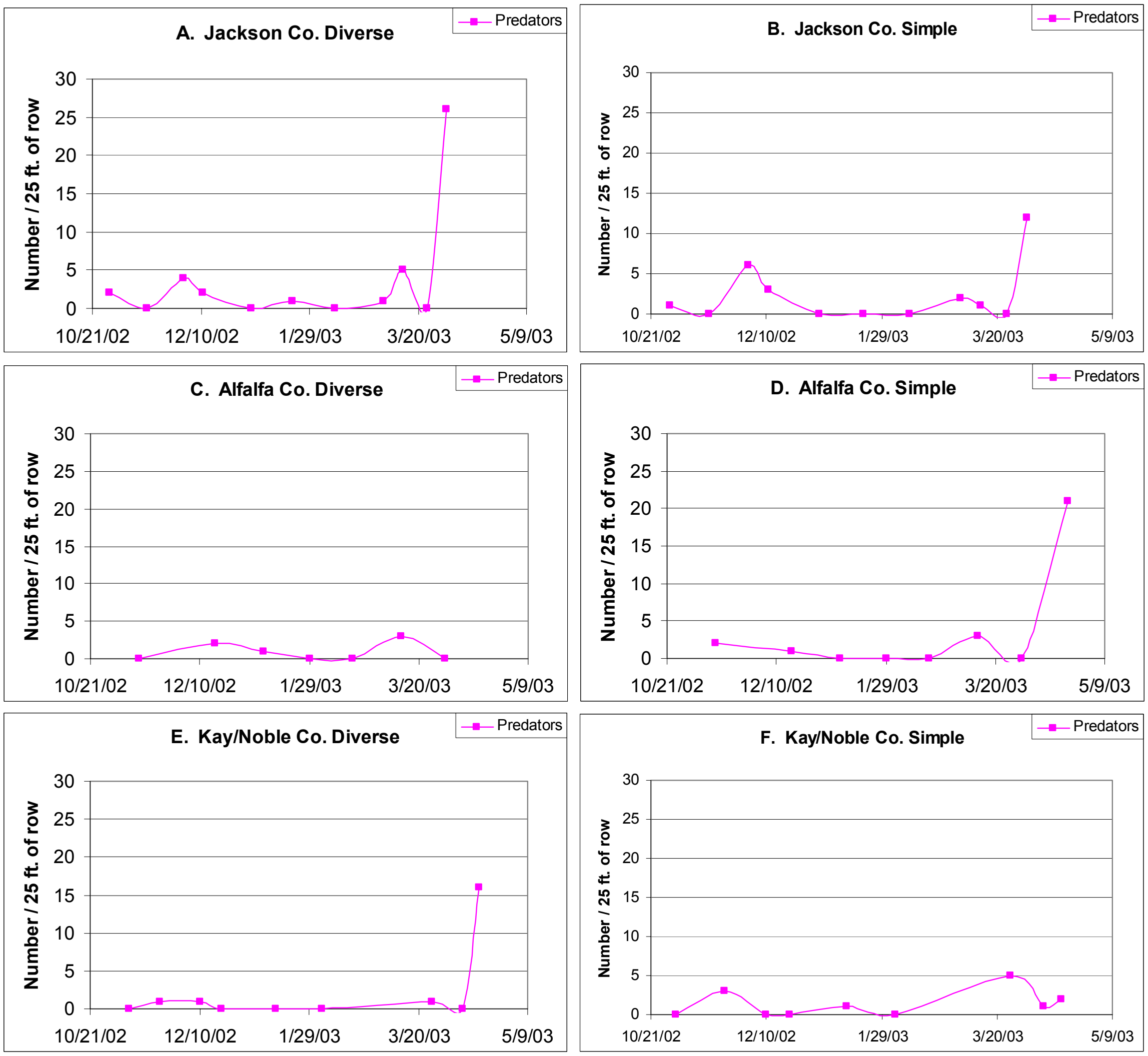


Figure 5. All arthropod predators in Winter Wheat at Oklahoma Demonstration Sites. Numbers were summed over twenty five 12"-visual samples.

Predators from visual and sweep samples. Predators in general were found at low levels in all of the fields evaluated (Figs. 5 and 6). Higher peak numbers of predators were found at diverse sites (vs. simple) at Jackson and Kay/Noble demonstration sites. At Alfalfa County, predator numbers were higher at the simple site; it is important to notice however that the landscape differences in Alfalfa County were minimal. Predator numbers appeared to be related to aphid numbers; when aphids were abundant, they likely supplied significant prey for predators.

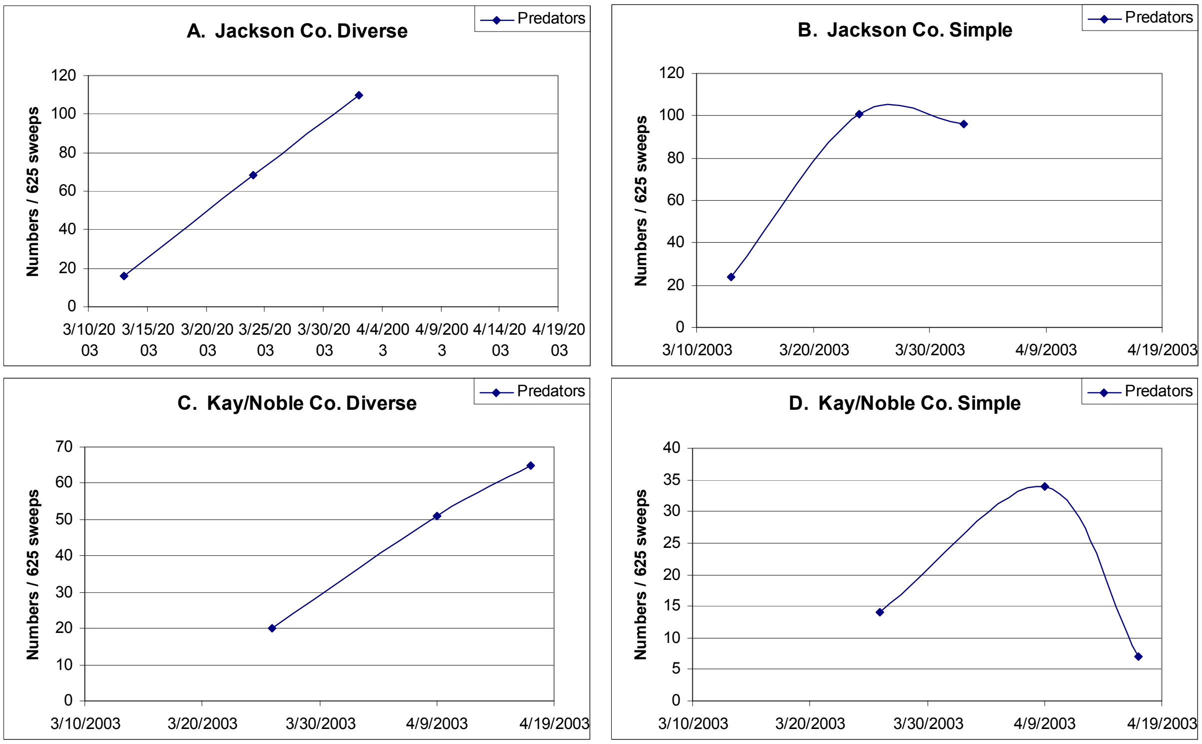


Figure 6. All arthropod predators in Sweep Samples in Winter Wheat at Oklahoma Demonstration Sites. Numbers were summed over twenty five 25-sweep samples.

Other Measures

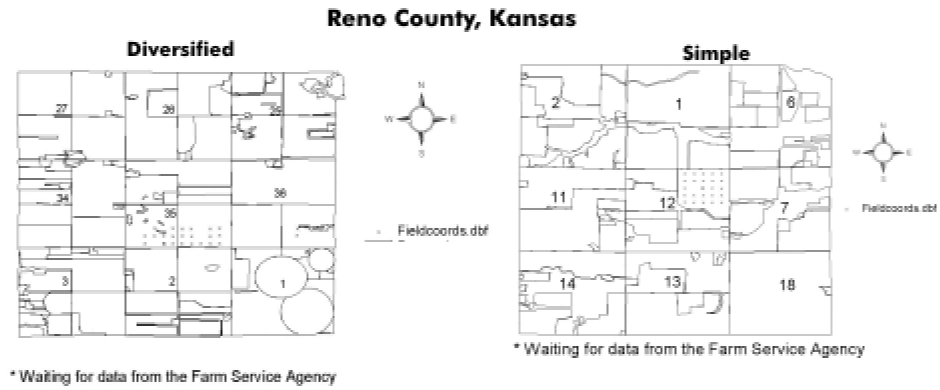
Weeds. In general weeds were found at low-to-moderate levels in all of the fields evaluated, and no significant differences were observed between diverse and simple sites. Data is continuing to be summarized.

Arthropods in alternative crops. In sorghum, aphids were present at all sites, but were severely reduced by parasitism (*L. testaceipes*). This primary parasitoid is the same that attacks aphids in wheat. The high levels of parasitism throughout the sorghum growing season suggests that *L. testaceipes* is conserved in diverse systems.

In cotton (at the Jackson Co. diverse site), cotton aphids built up quickly after planting, but were dramatically suppressed by an abundance of predators. Ladybeetles were observed to be the primary predators. Parasitism of cotton aphids by *L. testaceipes* was not observed. Data from sorghum and cotton fields is continuing to be summarized.

e. Kansas Demonstration Site

Phase II, Year 1 (2002-2003)
Prepared by Michal Roberts



Kansas had two field sites located in Reno County, Kansas. One (wheat only) represented an area in which a large percentage of the wheat is grown continuously. The other (diversified area) was located in an area where wheat is often rotated with other crops (sorghum, sunflowers, soybeans) in a more diversified cropping system. In fall 2002, both fields were mapped and gridded with 25 grid points and 4 benchmark areas. In the diversified area wheat was planted into wheat stubble, followed by sorghum. The fall 2003 wheat planting was made in a field planted to soybeans in the summer 2003.

Soil samples for soil fertility assessment and available soil moisture were taken at planting. Dr. Peeper of Oklahoma State University made the weed assessments in both fields. Fields were sampled for pest and beneficial insects at biweekly intervals throughout the growing season, weather permitting. Data was placed into a handheld unit and problems were encountered in retrieving the data due to corrupted software. This technical difficulty is currently being address by the software company.

Although our data is currently trapped in a software glitch, we detected no pest pressure in either field. There were only a few greenbugs (GB) and bird cherry oat aphids (BCOA) noted throughout the season. No Russian wheat aphids were found. Initially in the spring we detected no pests, and a few beneficial insects. Later in the season (late May to early June), beneficial insect and spiders were present in significant numbers; however, only a few or no aphids or parasitoids were present.

2. Progress Towards Automated Data Entry and an Internet Based Pest Alert System

Prepared by Vasile Catana

Data Sources and Methodology

The team involved in the AWPM project is collecting data on 23 fields located in different states as outlined in earlier sections of this document. The size of each field is around 120 acres and they are distributed throughout the Great Plains. On each field a grid of 25 uniformly distributed sampling points is established and each time they use the GPS tool to identify the points and a Pocket PC to register the data in Excel format. Everywhere they use identical entomological methods in the field and in the laboratory, so data are comparable. The sampling includes at least four vegetation periods on seven different crops characteristic for each zone: wheat, sunflower, soybean, sorghum, cotton, alfalfa, and millet.

In addition to the aphid information described in the introduction, the entomologists collect and register data on about 18 important predator species, five parasitoid species, and 15 weed species. These 15 weed species can be considered as a refuge places and reserves for aphid populations in specific vegetation phases. All the information from the Pocket PC is downloaded in Excel format files on a Windows PC in laboratory. At the USDA-Ars PSRL, Stillwater, OK we organized a server with Microsoft Windows 2000 Advanced Server© that contains MS IIS (Microsoft Internet Information Service). In the future we will replace it with Windows 2003 Server that has a more efficient IIS service than version 6.0. On this server we installed Oracle 9i AS RDBMS© and we organized an AWIPM database with tables corresponding to the structure of our collected information. With Visual Studio 6.0 we developed an independent Visual Basic application that can be deployed on any PC that runs the Windows operating system once Oracle Net Manager© is installed on it. Oracle Net Manager contains all required objects used in the Visual Basic application to make a link between the client computer and the server database computer. The Visual Basic application has the following four functionalities:

1. A user login to a database using a user name and password with the possibility to change the password.
2. Data view of all information beforehand introduced by other users from other places.
3. The capability for each user to modify/correct only his/her data.
4. Data input into corresponding database tables from existing Excel tables.

The last functionality is complex, because it contains the structure detection and data validation of all information in each type (format) of the Excel tables. If the Excel table contents an error or other format inconsistency, the user will be prompted with a message about the type of the error and its place (coordinates) in the table. At the present time we have developed this part of the application for only eight Excel format tables and we have to do it for another six. The structure of each future table has to be coordinated with all participants from the project and it has to take into account the work volume we have to do subsequently to the database.

The VB application will be sent to all participants involved in the AWIPM project in the near future. Each computer that will run the VB application has to be configured only once by installing the Oracle Net Manager on it. The Oracle Net Manager is free software and can be downloaded from the Internet (from the Oracle Corporation site). At the installation the user has only to indicate the parameters and the IP address of the database server. When the VB

application is running it makes a link with our database on the server via the Oracle Net Manager.
From the inside of the IIS we can make a link between AWIPM database and a web site located on the same or on a different server. In the future we will develop more complex web pages using ASP (Active Server Pages) and giving the possibility to all growers to know what currently happen with the aphid populations in their region. We will tray to do some link between our AWIPM database and the SAS software for result interpretation.

Anticipated Uses for the System

All sampling points in our researches have their geographic coordinates, so we can represent the information about the densities of aphid species and their enemies using the GIS software at both small (field) and large spatial scales (Great Plains). Because GIS is a tool that allows assembly of geographically referenced and nongeographic data on different ecological properties, we can integrate them with other software and modeling methods to generate new information. We can also derive new data that are syntheses of these data, and analyze the new data to map spatial variables such as habitat, species distribution, and movements of individuals. 1998).

First of all using our AWIPM database we will be capable of constructing maps of the Great Plains with the complete view of the current aphid situation corresponding to the most recent introduced data from all places involved in project. This kind of presentation can be very useful for the grower community because it will be operative, current, and precise. It is known that periods with relatively low aphid densities alternate irregularly with periods where outbreaks of aphid populations occur. If such an outbreak occurs in a location growers will pay more attention to the pest situation in their fields during this critical period. Later we will concentrate our attention on these outbreak periods to figure out what are the preliminary conditions that provoke them, like temperature, precipitation, beneficial entomofauna, etc.

As our database increases in size it will become more useful in our future studies to determine the causes and conditions under which aphid outbreaks occur. We need more statistics about the spatial and temporal distribution of all studied insect populations. The modifications of the models (1) – (3) can help us to elucidate the character of the interaction between aphid populations and their parasitoids and predators. They can serve as a starting point in our simulation models and other applications such as artificial intelligence tools.

The models (1) – (3) are useful for spatial and temporal population descriptions at the qualitative level. In order to simplify them and to determine analytical solutions (trajectories and surfaces) it assumed that their parameters are constant. In reality all the parameters are functions of the environmental factors; they reflect the specie physiology and reaction to particular (concrete) conditions. The best example in this sense for aphids is the intrinsic rate of population increase that changes with temperature.

Particularly the sampling of specific fields at certain dates can be considered as particular solutions for some generalized model (3). Using kriging or interpolation methods we can construct exact surfaces that represent solutions (realizations) of such a generalized model. Under these conditions we can try to solve the inverse task, to give a concrete parameterization to the model (3) knowing its quotient solutions. In the future we can test these new identified spatial-temporal models (3) using newly collected data. Because all data have their locations using GPS it will be a relatively easy task.

3. Research Component Summaries

a. Remote Sensing of Greenbug and Russian Wheat Aphid Infestations

Prepared by Norm Elliott, Mustapha Mirik, Jerry Michels, Kris Giles, Tom Royer, Mahesh Rao, and David Waits

In Phase I of the AWPM project, we conducted three independent field studies during the fall of 2001. These studies were also partially funded by a USDA-SBIR Phase I grant. Together, the studies demonstrated the feasibility of detecting greenbug infestations in winter wheat fields using a commercially available multispectral imaging system called the SST CRIS Crop Reflectance Imaging System (SST CRIS).

In the first study, we artificially infested two 3x3-m plots in a 0.4-ha wheat field with large numbers of greenhouse-reared greenbugs in early October, 2001. The objective of the study was simply to determine if we could visually identify the greenbug infested plots in SST CRIS imagery of the field. SST CRIS imagery was obtained using a Cesna-172 aircraft with the SST CRIS mounted vertically inside the fuselage of the aircraft. The field was imaged at approximately biweekly intervals from two weeks after infestation of the plots with greenbugs until the plots could be easily detected visually in SST CRIS imagery. By the second over-flight on October 25, 2001, the infested plots were visible in the SST CRIS imagery, and by the third over-flight on November 6, 2001 they were very visible (Figure 1). By November 6, the injury was clearly visible with the naked eye of a person standing near the plots as yellowed areas in the wheat field. While the results were encouraging they did not confirm that there would be a distinct advantage to using the multi-spectral imagery acquired by SST CRIS compared to ordinary color photography for detecting greenbug injury to wheat.

In the second study, we determined if greenbug injury to wheat plants could be detected in a typical field situation. In that study, 80 1-m^2 plots in a 0.8 ha wheat field near Perkins, Oklahoma were artificially infested with greenbugs at varying levels. The greenbugs used for infesting plots were reared in a greenhouse on wheat plants growing in 6-in. diameter pots. Plots were infested with varying numbers of greenbugs, ranging from no greenbugs to all the greenbugs from the foliage from four 6-in. diameter pots. Approximately two weeks after infestation, we commenced imaging the field at approximately biweekly intervals using the SST CRIS imaging system mounted in the Cesna-172 (Figure 2). At approximately the same date of

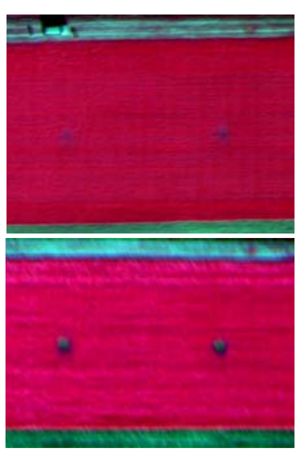


Figure 1. SST CRIS Crop Reflectance Imaging System imagery of an experimental wheat field near Perkins, Oklahoma for two dates in fall 2001: A) October 25, 2001 and B) November 6, 2001. Images adjusted to true reflectance.

each over-flight, greenbug density in each plot was determined by sampling 10 tillers from the plot and counting the number of greenbugs on each tiller. By the third sampling date (November 6, 2001) there was a statistically significant negative linear regression relationship between the normalized differenced vegetation index (NDVI) calculated from the red and NIR bands of SST CRIS normalized reflectance imagery and greenbug density (Figure 3). The existence of a statistically significant relationship between the density of greenbugs and NDVI in SST CRIS imagery clearly indicated that the injury caused by greenbug feeding on wheat plants could be detected using SST CRIS imagery. Furthermore, and most important, the injury was detectable at an earlier stage in its progression than could be detected by the human eye, because the plots were not obviously discolored by November 6 (the date the imagery was acquired). Greenbug densities in fields requiring insecticidal treatment to protect wheat yield typically range from 5 -

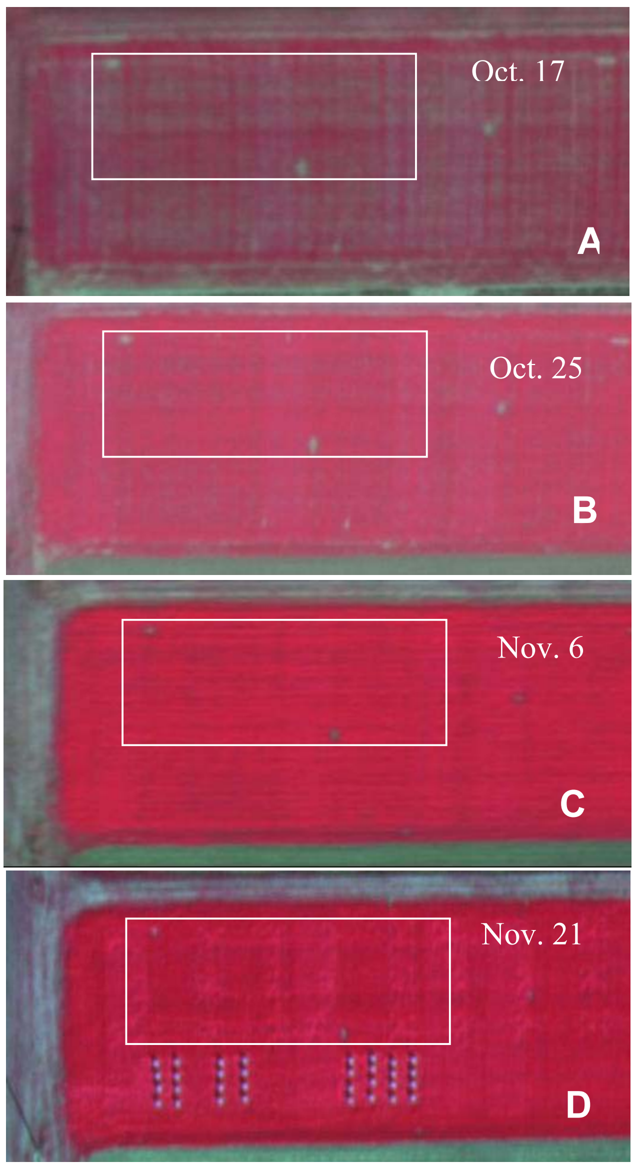


Figure 2. SST CRIS imagery of the area of a wheat field near Perkins, Oklahoma where 80 1-m^2 plots were infested with greenbugs. Plots with high greenbug density are vaguely identifiable in images C and D as small, darkened areas scattered throughout the white rectangle (which roughly indicates the area containing the 80 plots. All images were adjusted to normalized reflectance.

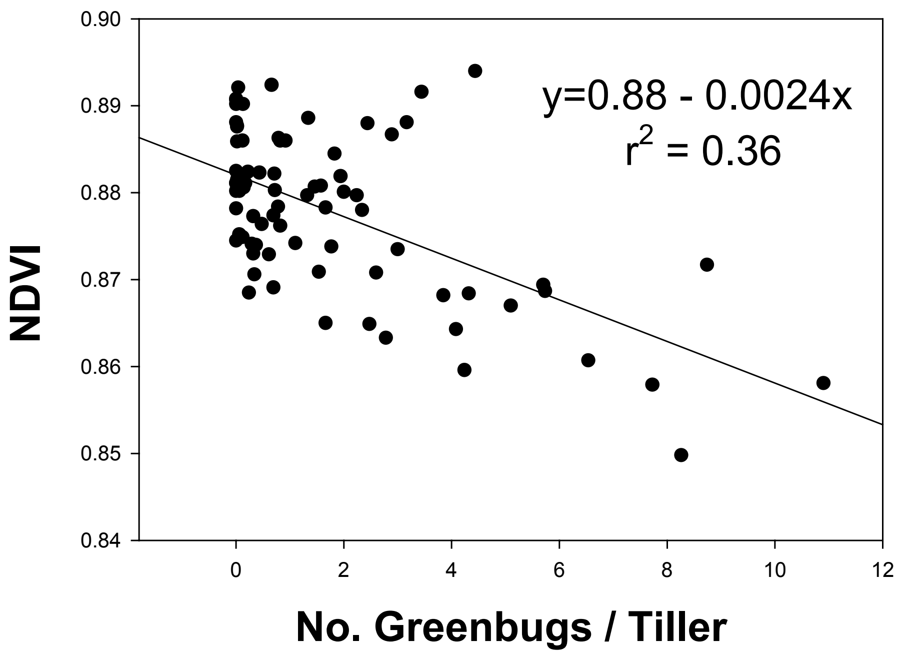


Figure 3. NDVI calculated from the NIR and red bands of an SST CRIS image acquired on November 6, 2001 versus the density of greenbugs in 1-m^2 plots in a wheat field near Perkins, Oklahoma.

12 greenbugs per tiller. Thus, an additional result of this study was verification that greenbug infestations could be detected using SST CRIS imagery at densities at or below those typically requiring insecticidal treatment.

The third study of the project was designed to determine if we could detect the spatial variation in greenbug density and plant injury in a wheat field naturally infested with greenbugs. To accomplish this study we scouted numerous wheat fields in Oklahoma during fall of 2001. Natural infestations of greenbugs were hard to locate during fall of 2001, but we were able to identify fields near Apache, Oklahoma where greenbug infestations occurred. In most of the fields, greenbug densities were in decline due to parasitism by natural enemies. We identified a field belonging to Mr. Paul Jackson where parasitism rates were low, and where consequently, the greenbug population would continue to increase in density. A drawback to the use of the field was that wheat plant growth in the field was highly variable for reasons other than the injury caused by greenbugs (Figure 4A). This heterogeneity made it very difficult to detect plant injury caused by greenbugs from other sources of heterogeneity in plant growth occurring within the field. We conducted an over-flight of the study field on December 18, 2001. The field was imaged from an altitude of approximately 1500 ft above ground level using an SST CRIS mounted in a Cessna 172 aircraft. At that altitude pixel size was approximately 13 x 13 cm. Several white cardboard panels were placed uniformly throughout the study plot prior to imaging, and the location of the center of each panel was determined using a global positioning system (GPS) instrument. The SST CRIS image was registered to the sampling grid using the known locations of the cardboard panels, which were clearly visible in the imagery.

Ground-based sampling was accomplished in the study field from December 18-20. A 95×95-m study plot was established in the field approximately one hour after the over-flight was completed. Sampling was undertaken at 400 pre-determined sample points arranged uniformly on the grid that spanned the 95×95-m study plot. Thus, sample points were 5-m apart within rows and columns of the grid. Wheat tillers were cut below the soil surface at three locations within 1-ft. of each of the 400 plastic stakes that marked the sample points (Figure 5). The tillers were placed in a plastic bag, labeled with the location of the stake, and returned to the laboratory

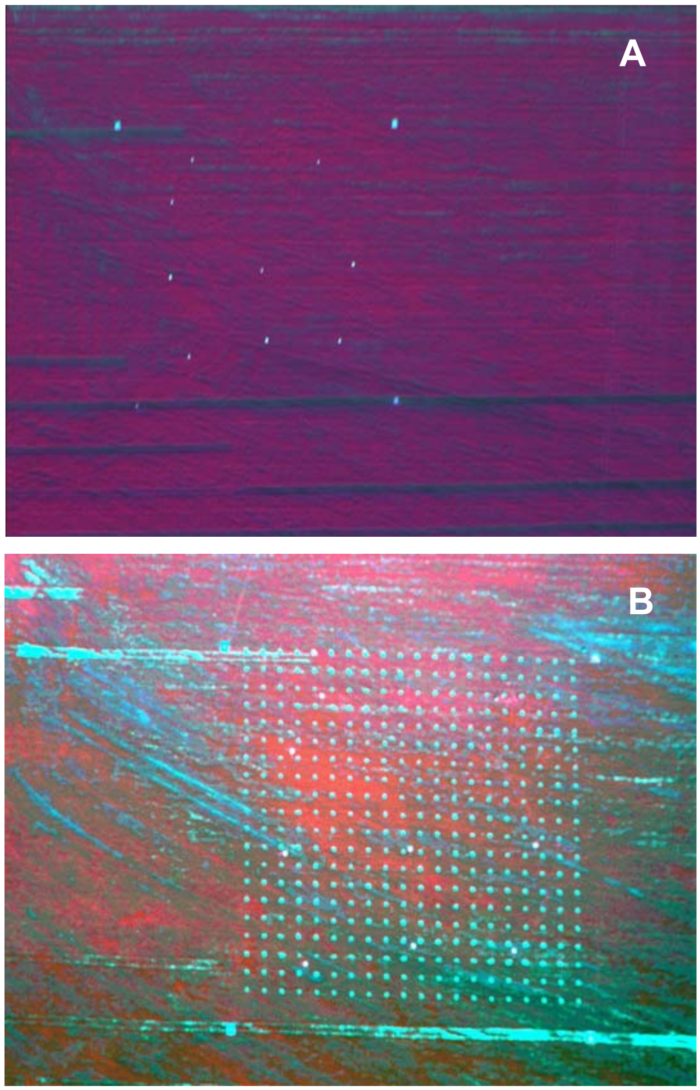


Figure 4. SST CRIS images of a wheat field near Apache, Oklahoma: A) image acquired December, 18, 2001, adjusted to normalized reflectance; B) image acquired February 5, 2002, not adjusted to normalized reflectance. Locations of white panels used as ground control points are visible in each image. Image 4b clearly shows the locations of the 400 sample points where wheat had been killed using herbicide.

where the greenbugs and number of tillers cut were counted and recorded.

Injury to wheat plants caused by greenbugs was rated at each sample point by cutting three tillers from different locations within 1-ft. of the plastic stake. Each tiller was rated according to the degree of greenbug-induced injury, using a damage rating system. According to the rating system, a tiller was given a rating of zero if no visual damage was present, and damage severity rating increased by integer values to a maximum value of 6 for a dead tiller. As a second measure of plant injury, relative wheat plant chlorophyll level was measured on each of the three tillers using a Spectrum CM-1000® hand-held chlorophyll meter.

A smaller study plot was superimposed on the 95×95-m study plot (Figure 5). The smaller plot was 25×25-m in size and included a total of 100 sample points arranged uniformly at distances of 2.5-m apart within rows and columns. Greenbugs, plant injury, and relative chlorophyll were measured using the same procedure as for the 95×95-m study plot.

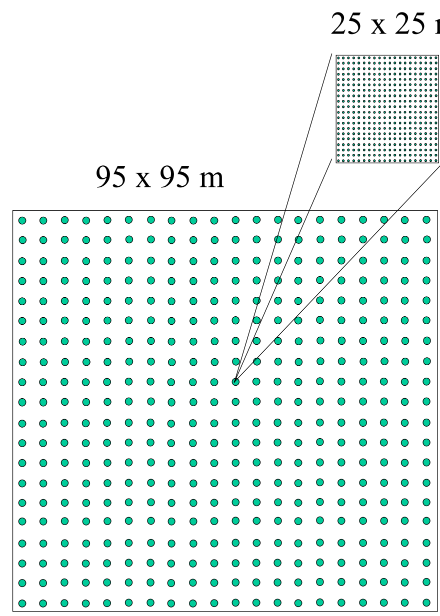


Figure 5. Plot design for ground-based greenbug, wheat plant damage, and relative chlorophyll sampling.

We evaluated reflectance patterns in the SST CRIS image using ERDAS Imagine 8.4© image analysis software. NDVI was calculated from the red and NIR wavelength bands of SST CRIS normalized reflectance imagery in order to visualize variation in reflectance patterns caused by spatial variation in greenbug density within the field. In order to ensure that we correctly located the pixels corresponding to the location of each sample point in the study plot, Roundup® herbicide was used to kill the wheat plants at each of the 400 sample points in the 95×95-m study plot after we had completed sampling. After the wheat plants had died, a second over-flight was made in which the field was imaged using the SST CRIS. White cardboard panels were placed uniformly throughout the study plot at the same locations as in the first over-flight. Areas of dead wheat plants were easily seen in the second image (Figure 4B). The centers of the white panels were used as ground control points for image registration. After registering the images, pixels for each band and for NDVI in the December 18, 2001 image centered on the location of the dead plants were extracted for categories of 3x3, 5x5, 7x7, and 9x9 pixels. The same procedure was used to obtain NDVI data for statistical analysis for the 25×25-m study plot. Mean NDVI was calculated for all 400 groups of pixels in each pixel number category for the 95×95-m plot and also for the 25×25-m plot. Pearson correlation coefficients for greenbug density, plant damage rating, and relative chlorophyll versus mean NDVI were calculated for data from the 95×95-m and 25×25-m study plots.

Correlations between NDVI and greenbug density, plant damage, and relative chlorophyll levelwere significant for all pixel groupings for the 95×95-m study plot (Table 1). Correlations of NDVI versus greenbug density and plant damage rating were significant for all pixel groupings for the 25×25-m plot, but correlations of NDVI with relative chlorophyll were not significant for pixel groupings on the 25×25-m plot. In spite of significance, correlation coefficients were very small. We think that the high degree of heterogeneity in wheat plant growth within the study field was partially responsible for the small correlations. This statement is supported by the observation that correlations for greenbug density and damage rating for the 25×25-m plot were generally larger in magnitude than those for the 95×95-m plot. This probably occurred because less variability in wheat growth was encountered in the small area encompassed by the 25×25-m plot compared to that in the much greater area of the 95×95-m plot.

Table 1. Pearson correlation coefficients for greenbug density, relative chlorophyll level, and plant damage rating versus NDVI for an SST CRIS image of a wheat field near Apache, Oklahoma acquired on December 18, 2001.

NDVI	Greenbug Density	Relative Chlorophyll	Damage Rating
95-m^2 Study Plot			
3x3 pixels	**-0.25***	**0.20***	**-0.25***
5x5 pixels	**-0.25***	**0.21***	**-0.26***
7x7 pixels	**-0.25***	**0.21***	**-0.27***
9x9 pixels	**-0.26***	**0.21***	**-0.27***
25-m^2 Study Plot			
3x3 pixels	**-0.37***	**0.16**	**-0.31***
5x5 pixels	**-0.38***	**0.16**	**-0.30***
7x7 pixels	**-0.38***	**0.16**	**-0.30***
9x9 pixels	**-0.37***	**0.16**	**-0.30***

* Correlation differs significantly from zero (P<0.01).

Another factor accounting for the small correlations was the sampling processes used to estimate greenbug density, plant damage rating, and relative chlorophyll. Even though the sampling methods were very time consuming, they were fraught with very high sampling errors, and in the case of estimates of greenbug density, bias that occurred among the five individuals that counted the samples. We believe these factors seriously reduced the evidence of the true strength of the relationship between NDVI and the measures of greenbug population density. Use of less error prone methods for ground-based sampling would have resulted in stronger correlations. However, it is very important to note that even under very poor circumstances we were able to document a relationship between NDVI in SST CRIS normalized reflectance imagery and the three measures of spatial variability of greenbug density within a wheat field.

There was no decrease in correlation of NDVI with greenbug density, plant damage, and relative chlorophyll as pixel grouping increased in size from 3x3 to 9x9 pixels (Table 1). This suggests that patches of greenbugs of various densities within a field occur at a scale larger than the ca. 1.15 x 1.15-m area of the largest pixel grouping we created. This result indicates that patches within a wheat field with varying densities of greenbugs are large enough to be detected in SST CRIS imagery even if pixel size was as large as 1-m^2.

Summary

We demonstrated through the series of experiments that: 1) Areas of greenbug infested wheat within a field can easily be distinguished from healthy wheat in a false color composite image of green, red, and near infrared (NIR) bands of normalized reflectance SST CRIS imagery; 2) There is a strong negative linear relationship between greenbug density and NDVI calculated using the red and NIR bands of normalized reflectance SST CRIS imagery; 3) Greenbug infestations can be detected using NDVI calculated from SST CRIS imagery at densities below typical treatment thresholds; and 4) Spatially variable greenbug infestations in a wheat field can be differentiated in an NDVI image calculated using the red and NIR bands of normalized reflectance SST CRIS imagery. These four results provide strong evidence that remote sensing using the SST CRIS can be used to detect greenbug infestations in wheat fields before insecticide application would typically be required to protect the crop from economic losses. Furthermore, the project laid a firm foundation for future research to develop methodology to detect infestations of greenbugs at both the whole field and sub-field levels using the SST CRIS imaging system, from which we believe we can develop an operational greenbug detection system.

b. Natural Enemy Dynamics in Diversified Cropping Systems

Prepared by Mpho Phoofolo

Introduction

A research component of the AWPM project was to unravel details of the dynamics of aphid natural enemies within diversified cropping systems compared to mono-cultural wheat only cropping systems in order to be able to better predict the effects of particular cropping system configurations on biological control of greenbugs and Russian wheat aphids in wheat agroecosystems. During the summer and autumn of 2003 plans were developed and research was initiated to address this problem. Both field and laboratory studies were deemed necessary to unravel the complexities of how predators utilize prey in complex wheat agroecosystems compared to simple, wheat only, systems.

The overall objective of the laboratory study is to test the potential applicability and robustness of stable isotope analysis to insect predator-prey trophic interactions in an environment where most of the contributing factors can be manipulated and/or controlled. In other words, the study is aimed at developing a set of standards against which the use of stable isotope analysis in the field can be based. Specifically, the study is designed to:

1. determine the relationship between the $\delta^{13}C$ and $\delta^{15}N$ in insect predators relative to ratios in the aphid prey and host plants;
2. assess the isotopic turnover rate/time in predators relative to diet changes (aphid species);
3. test the performance of the linear mixing models in reconstructing the diets of aphidophagous insect predators.

The objective of field studies is to determine why natural enemies of aphids are more abundant in diverse versus simple wheat dominated landscapes and diverse versus simple wheat dominated within-farm cropping systems. More specifically, we seek to determine how the mix of crop and non-crop vegetation influences populations and communities of natural enemies at landscape and field scales. The paragraphs that follow outline the laboratory and field research that we designed and initiated to address these issues.

i. Methods for Laboratory Research on Natural enemy Dynamics

Relationship between $\delta^{13}C$ and $\delta^{15}N$ in predators relative to ratios in aphid prey and host plants.

The leaf tissue from each plant species (alfalfa, sorghum, and wheat) will be collected and then freeze-dried to make three 20 mg samples per species for isotopic analysis. To determine whether different aphid species from the same host plant have the same or different isotopic signatures, several aphids of each species in Table 1 will be collected into glass vials and dried to make four 10 mg samples.

Table 1. Aphid species for determining taxon-specificity in isotopic signatures.

Host plant	Aphid species
Alfalfa	A. pisum, A. kondoi, and T. maculata
Wheat	S. graminum, D. noxia, and R. padi
Sorghum	S. graminum and R. maidis

To determine taxon-specificity in isotopic signatures among the predator species with the same feeding history, two sample populations of lady beetle larvae from each of the most commonly occurring species in (central) Oklahoma annual crops (i.e., Hippodamia convergens, Coleomegilla maculata, Coccinella septempunctata) will be reared from 1st instar to pupal stage. One population of each species will be fed pea aphids (or any one of the available aphid spp. from alfalfa) and the other population fed greenbugs. Upon becoming adults, 10 beetles (5♀ and 5♂) will be randomly selected from the population and frozen within 24 hours post-emergence for isotopic analysis before any adult feeding takes place.

Isotopic turnover rates.

Isotopic turnover rates will initially be determined only on H. convergens. If results on taxon-specificity in isotopic signatures among lady beetles show significant differences among species, turnover rates in C. maculata and C. septempunctata will be determined later. H. convergens adults will be obtained from the sample population reared from 1st instar to pupae on pea aphids. Within 24 hours of becoming adults beetles will be randomly subdivided into 4 groups (treatments): (i) the control group, which will continue on the same aphid prey as the larvae, (ii) the group which will be switched to a diet of greenbugs, (iii) the group switched to a mixed diet of greenbugs and pea aphids (in constant pre-determined proportionate amounts), and (iv) the group switched to a mixture of greenbugs, corn leaf aphids, and pea aphids (in constant pre-determined proportionate amounts).

Subsets of 8 beetles (4♀ and 4♂) will be selected from group (i) on the 10th, 20th, and 40th day post adult emergence, held with water but no food for 24 hours (to allow emptying of food material from their guts) before being frozen for isotopic analysis (fewer sub-samples because no turnover is expected in this group). To determine the isotopic turnover rates in beetles that switch diets (i.e., groups (ii) to (iv)), subsets of 8 beetles (4♀ and 4♂) will be serially selected from each group, held with water but no food for 24 hours then frozen for isotopic analysis. This sub-sampling will be done every other day for the first 10 days post emergence and thereafter on the 14th, 20th, 28th, and 40th day post-emergence. Sub-sampling is more frequent at the beginning of the experiment so as to accurately determine the turnover pattern/trend as well as the half-lives of the (isotopic) elements in the selected predator tissues.

Two separate isotopic analyses will be performed on each individual, one on the forewings (elytra) and the other on the remaining body (i.e., w/o elytra). The elytra are analyzed separately because they are made of materials that are believed to become rather metabolically inert following wing synthesis and therefore are not expected to show rapid isotopic turnover for beetles that switch diets after reaching adult stage. Therefore, the working hypothesis is that stable isotope analysis on the elytra will reveal the larval diet histories of individual beetles whereas the analysis on the body will reveal the adult diet history (i.e., recent feeding record).

Sample preparation for isotopic analyses

Prior to being sent for isotopic analysis all the samples (of plants, aphids, and predators) will be either oven-dried or freeze-dried, ground into fine talcum powder consistency using a ball mill, and then sealed into 5 x 9 mm tin capsules. These capsules will then be shipped to any of the laboratories that will be chosen to do the stable isotope analyses.

Reconstruction of proportionate contributions of diet sources by the linear mixing models

Once the $\delta^{13}C$ and $\delta^{15}N$ for plants, aphids and lady beetles are known proportionate contributions of different (aphid) species to the predators will be determined by manual calculations using equations (3a) and (3b) for predators that were fed a mixed diet of two aphid species and equations (5a), (5b), and (5c) for predators fed a diet of three aphid species. Results from manual calculations will be confirmed by using the Excel spreadsheet program made available at http://www.epa.gov/wed/pages/models.htm for performing calculations for both a two-source model and a three-source model.

Data analysis

Data will be subjected to various appropriate statistical tests.

ii. Methods for Field Research on Natural enemy Dynamics

1. Wheat

Sampling in fall and spring with sampling frequency per plot based/dependent on levels of aphid infestation.

Instead of (VS):

Sampling during each of the 5 phenological/developmental wheat stages (i.e., tillering, stem elongation, boot, head emergence-flowering, and the soft dough stage).

a. Aphid pests: -
    - Determine plant growth stage
    - Divide each plot into 2 (east and west) subplots
    - Randomly collect 50 tillers per subplot by traversing each subplot and picking 10 tillers at approximately every 30 feet (Giles et al 2000).

b. Predators (coccinellids, chrysopids, anthocorids, nabids, syrphids, carabids, staphylinids, and spiders)

   All predators will be sampled using the following combination of methods:

   1. Random placement of 0.5 m^2 quadrats in 3 random locations per subplot
   2. Sampling of each quadrat for 1.5 minutes with a suction sampler
   3. Immediate careful ground searching and collecting of predators in the area just vacuumed (may exclude depending on suction sampler performance)

- Density is estimated by pooling counts from suction sampling and visual ground search

2. Sorghum

Sampling done during each of the following 5 phenological/developmental sorghum stages (stage 2 = collar of fifth leaf visible, stage 3 = growing point differentiation, stage 4 = final leaf visible in whorl, stage 5 = boot stage, and stage 6 = half bloom).

(a) Aphid pests: - Greenbugs and other aphids will be sampled similarly regardless of the plant developmental stage.

- o Determine plant growth stage
- o Count aphids on 10 randomly chosen plants
- o Count plants in two 1.0-m sections of row

OR

- o Count aphids in all plants in 1 m of row in 4 randomly chosen locations

(b) Predators – use one of the following:

- o Visual counts per plant (Kring et al 1985; Tyler et al 1974; Lopez & Teetes 1976) on 10 plants
- o Visual counts on all plants in 1 m of row from four randomly chosen locations (Parajule et al 1997)
- o Quadrat sampling involving counting all predators trapped within a 0.5 m^2 or 1.0 m^2 area from 3 or 4 random locations per plot (Michels et al 1996)
    - ▪ Maybe combined with suction sampling

3. Alfalfa and cotton

- o Purpose of predator and prey density estimates from alfalfa and cotton?
    - o Correlation with predator density in adjacent intercrops
    - o Within crop comparisons across years

Monitoring/sampling in alfalfa

- Aphid density/abundance determined by stem sampling (25 stems per subplot)

-
- Predator density/abundance determined by suction sampling as described above for wheat sampling; plus pitfall and sticky traps as described below.

Monitoring/sampling in cotton

- Sampling to span from the time the plants first true leaves to early open ball stage
- Visual count of aphids and predators on plants in 1 m of row in four randomly chosen locations per plot.
- Use of pitfall and sticky traps?

Dispersal and activity density

(a) Use of PCR based Stomach Content Analysis (genetic markers)

   i. PCR primers already existing for cereal aphids
   ii. Possibility of developing PCR primers for aphid spp. in:
      1. alfalfa e.g. pea aphid, blue alfalfa aphid
      2. cotton ?
      3. Do similar studies as that of Chen et al (2000)need to be made for different predator groups [just like done by Greenstone & Shufran (2003)

(b) Use of Stable Isotopic Analysis

   (i) Carbon isotopic signatures
   (ii) Nitrogen isotopic signatures

(c) Use of traps (pitfall and sticky)

Pitfall traps

Each plot of wheat (both in diversified and monoculture) will have 4 traps set up at random (permanent) locations. Guides (14 x 122 cm galvanized sheet metal strips) will be used to enhance trap capture efficiency and will be arranged such that 2 traps will have guides facing the alfalfa plot and 2 facing away from alfalfa. To compare predator abundance and activity between adjacent crops 2 sets of paired traps will also be set up simultaneously in the alfalfa plots. Predators caught on traps will be counted and removed every week.

Sticky traps

- Yellow Pherocon® AM sticky traps will be used
- Each trap will be mounted (stapled) on wooden stakes (2 feet above ground) so that the trap has two surfaces, east-facing and west-facing

Sticky trap arrangement per plot

- Each plot (of wheat (diversified and monoculture), alfalfa, sorghum, and cotton) will be subdivided into 2 subplots (east and west)
- 3 traps will be set up at random locations along a north-south direction in each subplot.
- Predators caught on traps will be counted every week and the traps will be replaced every other week.

Trapping (both pitfall and sticky) will be shifted from alfalfa/wheat to other crops as shown in the following Table:

Trapping period	Adjacent crops
Fall-winter-spring	Alfalfa and wheat
Spring-summer	Wheat and sorghum
Summer-fall	Sorghum and cotton
Fall	Cotton and alfalfa

4. Education and Sociologic Evaluation Component Summaries

Prepared by Sean Keenan, Paul Burgener, and David Christian

I. Report Overview

This report summarizes socioeconomic goals and accomplishments for the second year of the five-year project, "Biologically Intensive Areawide IPM of the Russian Wheat Aphid and Greenbug." Our primary goal in the second year was to recruit wheat producers in a six state area as participants in focus group discussions and economic cost-of-production interviews.

In brief, our specific goals and accomplishments for 2002-2003 were:

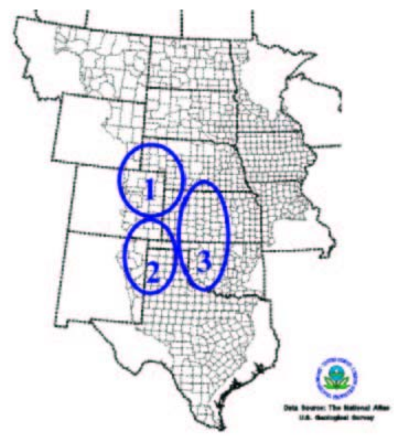
1. Recruit wheat producers from around the study region to participate in the project.
    - ✓ Upon completion of first year focus groups and cost-of-production interviews, we have 147 wheat producers as project participants.
2. Establish procedures for the protection of human subjects as participants and obtain necessary institutional approval.
    - ✓ We obtained approval from the Institutional Review Board at Oklahoma State University prior to conducting focus groups and interviews. We will submit a continuation for the second and subsequent years of interviews. (The University of Nebraska did not require us to request approval of this project.)
3. Conduct focus group discussions with paired groups of 8-10 producers in each study location.
    - ✓ 138 of the 147 participants attended one of 20 focus group sessions, conducted between January and March, 2003. Focus group discussions were transcribed. Transcripts have been entered into a database program and coded for further synthesis and analysis. We are still in the process of generating a complete focus group summary report.
4. Conduct the first of four annual cost-of-production interviews with each participant.
    - ✓ As of November 2003, we have completed first year cost-of-production interviews with all but 2 of the participants. This report provides some descriptive statistical summaries of the participant group by state and zones of the project region. We are currently generating farm budgets from interviews and will be providing these to participants prior to contacting them for second year interviews to be conducted between December 2003 and March 2004.

Section II of the report provides complete details regarding each of these goals and accomplishments for the year. Section III presents descriptive statistics from our first interview, describing farm operations of the participating producers, wheat varieties grown, and types of crop rotations utilized. This baseline data will be important background information for interpreting subsequent reports and in evaluating changes in production strategies occurring during the course of the project. Section IV concludes the report with a summary of plans for the third project year, including additional planned analyses of focus group and interview data and plans for the second year cost-of-production interviews with each producer.

II. Socioeconomic Assessment Goals and Accomplishments, 2002-2003

A. Selection of Participants

Goals. Project study locations would be counties with established demonstration field sites, plus surrounding counties to expand the area represented. (In practice, these would be areas within a reasonable driving distance for producers to attend half-day focus group discussions.) The larger project team had established a total of 22 demonstration field sites prior to the initiation of insect field sampling in the fall of 2002. These 22 fields consisted of 11 paired demonstration fields, with one field having either continuous wheat or a wheat-fallow rotation and the other field having a rotational system, with one or more alternate crops grown with winter wheat. The sites were distributed in three study area regions of interest, discussed in earlier project reports and illustrated in the figure at right.



Producers farming these demonstration fields would be included in focus group discussions and cost-of-production interviews. We would recruit an additional 7-9 producers for each of the established demonstration sites and approximately equal numbers of diversified-crop and "wheat only" producers distributed within the three study area zones. We would select participants in consultation with members of the project team, cooperative extension agents, local cooperatives, and wheat organizations in each state. We were interested in recruiting growers who were relatively successful at farming these contrasting systems and who were conscientious in their selection of production practices. (Thus, we acknowledged that our participants would not be a representative, or random, sample of wheat producers in the study region.)

Project participants. Participation of wheat producers in the project would initiate with focus group sessions. Working primarily with Cooperative Extension agents in twelve locations were we would conduct focus groups, we invited a total of 190 producers to focus group sessions. In most cases, Cooperative Extension agents made the initial contact with producers, followed by an invitation letter from the focus group moderator. The moderator or assistant moderator then made a personal phone call to each producer 1-3 days prior to the focus group, to remind them of the meeting time and to answer questions.

Upon completion of 20 focus group sessions, 138 producers had attended a focus group. An additional 12 who were not able to attend were scheduled for our cost-of-production interview. This gave us a total of 150 project participants to be interviewed after completion of focus groups. As of November, 2003 we hade completed a total of 145 interviews with 2 interviews yet to be completed and 3 individuals who refused to be interviewed (dropped their involvement in the project). Thus, the total number of participating producers by the end of the first year of program implementation was 147. Table 7 summarizes the number of participants by project zone and state. We provide additional breakdowns of participant numbers by focus group locations at the end of the report in Table 11.

Table 7. Number of demonstration sites and project participants by project zone and state, 2003

Project zones	States	Demonstration sites	Project participants
1	Nebraska	2	14
	Wyoming	2	14
	N. Colorado	2	18
2	S. Colorado	4	19
	Texas	4	27
3	Kansas	2	13
	Oklahoma	6	42
Totals		22	147

Consistent with the larger number of demonstration sites in Colorado and Oklahoma (6 in each state, with Colorado split between northern and southern areas), we have more participating producers in those states—a total of 42 in Oklahoma and 37 in Colorado. Producers in Nebraska and Wyoming combine for a total of 28 participants in that part of the study area. We have the least number of producers in Kansas because we have only two pairs of demonstration sites in that state, located in Reno County.

Cropping system characteristics of project participants. While we sought equal numbers of participants who would represent "wheat only" and "diversified" cropping systems, we understood that wheat producers would not fall neatly into these dichotomous categories. However, we did want to learn about producer's decisions to produce "wheat only" or to adopt alternate crops as part of a planned rotation. The separation of these groups did not need to be perfect, but to facilitate discussion we wanted participants in each focus group to have had common experiences in making these decisions. Since we knew the assignment of individuals to a focus group would be imperfect, we utilized the same focus group questions for all focus groups.

We relied on Cooperative Extension agents to assign growers to focus groups based on their knowledge about producers in their area. In some locations we had smaller numbers of participants at focus groups scheduled for "wheat only" producers. This left us with the impression that we had less success at recruiting producers who only farmed winter wheat. However, it was not until we completed our interviews that we were able to systematically assess cropping systems used by the project participants.

In the interview we asked producers to describe their typical crop rotations and the approximate number of acres they had in each system. We also recorded acres in continuous wheat or wheat-fallow systems. After coding these results and determining the number of different rotational systems described, we were able to summarize crop rotations for the participant group.

Figure 1 illustrates that out of 141 producers for whom we have crop rotation data, 33 produced “wheat only.” A larger proportion, 56 out of 141, described one or more planned crop rotations for all of their cultivated wheat acres (represented in the figure category, “all acres diversified”). The remaining 52 producers had some acres in a wheat only system and some in a diversified system. This category includes a broad spectrum of producers, including those who are primarily continuous wheat or wheat-fallow as well as those at the other end of the spectrum who have some limited acres in a wheat-only system for a variety of reasons.

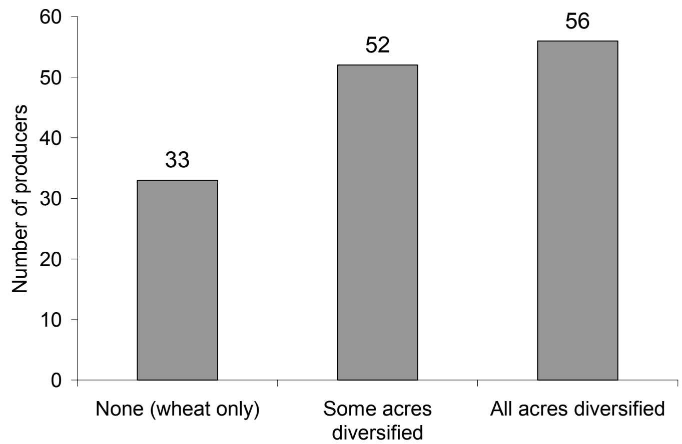


Figure 1. Three categories of crop rotations with dryland winter wheat, 2002 Cost-of-Production Interview

Another way to consider the use of crop rotations among our participant group is the percentage of the 141 interview respondents with “wheat only” systems and the percentage with one or more “diversified” cropping systems (recognizing that some have both types). About 77 percent of the 141 producers (109) had some or all of their acres in a “diversified” system, while about 60 percent (85) had some or all of their acres in a “wheat only” system. Again, these figures reflect the large overlap in the use of these types of dryland wheat cropping systems represented by the middle category in Figure 1.

The type of crop rotations used also varies greatly by producer and locality. We recorded a total of 92 different combinations of wheat, alternative crop, and fallow periods used in dryland cropping systems among the 141 interviewees.

In short, while our initial suspicions were correct—we did have fewer project participants with “wheat only” production systems—we where successful in recruiting a participant group representing a broad range of cropping systems currently used with dryland winter wheat in the project study area. We examine further details regarding crop rotations among our participant group later in this report. Additional analyses to follow this report will allow us to evaluate producers’ considerations in the adoption of crop rotations with winter wheat. Subsequent interviews and focus groups will allow us to evaluate any changes in production strategies.

Development of Project Brochures and Quarterly Updates to Facilitate Participation. As part of the grower recruitment effort it was necessary to develop some project educational materials and to establish a working relationship with Cooperative Extension personnel in each study area. The socioeconomic team met with groups of extension personnel in each study location prior to scheduling of focus group sessions. We also assisted in the development of a program brochure, a quarterly update mailing to keep everyone informed, and revisions of the project website. The focus group moderator developed a detailed information packet, detailing plans for the focus group sessions, for distribution to Cooperative Extension personnel and other interested parties.

Guidelines for the Protection of Human Subjects as Participants. The project team recognized that focus groups and cost-of-production interviews would be a form of research involving human subjects. As such, it would be necessary to follow established federal guidelines for the protection of human subjects. This would involve following procedures of Informed Consent and obtaining approval of focus group and interview questions from one or all of the Institutional Review Boards at participating universities on the project.

We requested review of our information collection procedures from Institutional Review Boards (IRB) at Oklahoma State University and the University of Nebraska. The Nebraska IRB did not require us to submit a formal review. We obtained approval for the administration of focus groups and our first cost of production interview from the IRB at Oklahoma State University on January 23, 2003. The approval expires on January 22, 2004, prior to which we must submit a request for continuation of the study for the second of four years in which we will be collecting information from project participants.

The crucial elements for protection of project participants as human subjects on this project are the use of an Informed Consent document to assure voluntary participation of subjects and the use of proper procedures to maintain confidentiality of information collected from subjects.

In following these procedures we utilized an approved Informed Consent document, completed by all project participants prior to their participation in focus group discussions. The Informed Consent details our purpose and procedures in information collection, anticipated benefits, and contact information for the project team. Participants signed two copies of the Informed Consent, one for our records and one for them to keep.

To maintain confidentiality of information obtained from project participants, we removed all names and personally identifying information from focus group transcripts. On interview sheets and in computerized data entered from interviews, we utilized nonsystematic subject numbers to maintain confidentiality.

B. Focus Groups with Producers

Project Goals. As indicated in the project proposal, the purpose of focus group discussions was to obtain baseline data on crop production methods in wheat and alternate crops, with emphasis on management of insects, weeds, and diseases. Focus groups would provide detailed information about crop production decisions from the producers' perspective. We also hoped to identify IPM information needs of producers in each of the two categories of production systems.

The *focus group* is an established research method in the social sciences. Focus group discussions are designed to be informal and nonthreatening, taking advantage of insights that can be gained from group discussion as opposed to a one-on-one interview or questionnaire administered by a researcher. Focus groups require careful preparation by a skilled moderator. The success of the focus group depends on creating a permissible environment for discussion while at the same time accomplishing the research goal of capturing the discussion for systematic synthesis and comparison. To assist in this process, focus group discussions would be audio recorded and transcribed.

In consultation with the Bureau for Social Research at Oklahoma State University, the project team determined that focus groups would be conducted in paired sets of three. The “three-of-a-kind” rule would provide a sufficient number of focus groups in each region for analysis of topics discussed. Following this rule, we would have a total of eighteen focus groups (two pairs of three focus groups—or a total of six—in each of three study area zones). However, in Zone 3 we conducted an additional pair of focus groups in southwestern Oklahoma, due mainly to the geographical distance of this area from other demonstration sites. This gave us a total of twenty focus groups.

Focus Group Outcomes. We conducted focus groups between January and March, 2003 as follows:

- ✓ Zone 1: Six focus groups—two each in Brush, Colorado, Scottsbluff, Nebraska, and Pine Bluffs, Wyoming. We conducted these groups between March 4 and March 6.
- ✓ Zone 2: Six focus groups—four in the Texas Panhandle between February 18 and February 27, and two in Lamar, Colorado on March 12.
- ✓ Zone 3: Eight focus groups—two in southeastern Oklahoma (Altus), four in north central Oklahoma (Cherokee and Blackwell), and two in South Hutchinson, Kansas. We conducted these groups between January 28 and February 11.

On most focus group days we held two focus groups in one location: a morning focus group with diversified crop producers and an afternoon focus group with “wheat only” producers. We typically provided a catered noontime meal for participants from both groups. This provided an opportunity to visit informally, introduce members of the project team, and establish a time frame for conducting the cost-of-production interviews with each producer. Cooperative extension agents were invaluable, both in selecting participants and in making local arrangements for focus group sessions.

We used the same question set for all focus groups. Figure 2 displays the focus group “question route.” In contrast to a questionnaire or structured personal interview, a focus group question route provides general direction for discussion. The initial one or two questions are presented in “round robin” fashion, whereby the moderator asks the group to “go around the table” to get acquainted and help everyone feel comfortable speaking in the group. Once the group appears at ease, the moderator poses subsequent questions to the group as a whole, allowing anyone to initiate responses and others to provide follow-up responses or clarifying questions. The moderator interjects to probe for details, to solicit responses from silent group members, or to move the discussion to the next topic.

Since questions are loosely structured and participants may respond to one another, useful information regarding topics covered may occur at any point in the discussion, not just in response to a specific question posed by the moderator. Consequently, the typed transcript is invaluable in reassembling the discourse at a later time to evaluate information obtained and to compare focus group sessions.

The Bureau for Social Research at Oklahoma State University provided transcription services. To facilitate analysis of focus groups, the focus group moderator converted typed transcripts into a textual database and analysis software program, C-I-SAID. The software enables the user to code discussion segments from transcripts, both to catalog the discussion and to create variables for analysis and integration.

A subsequent report will provide a detailed summary of focus group discussions including major wheat pest problems, limitations in adoption of crop rotations, use of resistant wheat varieties, and perceptions regarding insect scouting and beneficial insects.

C. Cost-of-Production Interviews

Goals for Interviews. Data from annual cost-of-production interviews will enable us to evaluate the economic effectiveness of cropping systems actually in use among the project participants. This will be accomplished by developing annual enterprise budgets, showing per-acre costs and returns, for dryland wheat, fallow, and each of the alternative crops. These budgets will summarize input and machinery costs for each cultural operation as performed through the production cycle. Enterprise budgets for individual crops will be consolidated into a simulated total farm budget.

In addition to providing our research team with a detailed view of the economic outcomes of various crop production systems, these budgets and subsequent reports will also provide a useful product and educational tool for participating producers. Annual budget reports will be generated for each individual producer.

Accomplishments for Interviews. As of November 2003 we have completed 145 of 147 of the first of four annual interviews with each producer. We entered results into spreadsheet format and tallied results.

Preliminary calculations for cost of production budgets are presently under way, with completion expected in time to use these when completing the second-year crop production interviews beginning in December of 2003. These budgets are anticipated to show the growers and research team the actual cost of production for each crop and for the system as a whole over time. Budget reports will be given to the growers and discussed during the second, third, and fourth interviews. Statistical analysis will be done to determine if there are significant differences in the production systems, regions, states, and crops being observed during this project. The next section of the report provides some initial statistical summaries of the production systems of our project participants from these interviews.

1. Briefly tell us about yourself:
    - Who you are
    - The place you consider home
    - How long you have been farming
    - Crops that you currently grow, including cattle if you run them.

    You do not need to tell us how many acres you produce or head of cattle you stock. Instead, just give us a sense of what you produce.

2. Let's go around the room one more time. Tell us about:
    - Crops you have grown in the past but no longer grow.
    - Any new crops you are thinking about growing (or new cropping practices).
    - Anything else you would like to add.

3. If a grower is thinking about a new crop (or new cropping practice) here, what are his greatest challenges or limitations in being able to do that?

4. How does your wheat look this year? (recently planted crop in your area).
    - Follow-up: We are interested in how you make decisions.
    - What were some decisions you made in planting your current wheat crop?
    - Are these the decisions you typically make?
    - If anything different, whom did you talk to about it? (What information did you consult?)

5. Now I am going to ask about weeds, plant diseases, and insect problems for wheat in this area. (Create a list on your index card as we mention some.)
    - What are some problem weeds for wheat fields in this area?
    - What are some wheat diseases you find here?
    - What are some insects you find in wheat fields here?

6. We have mentioned several types of pests in wheat, including insects, weeds, and plant diseases. With all of these in mind, **what have been your biggest pest concerns over the past year or two**?
    - Follow-up: How have you dealt with these?
    - Whom did you ask for advice? (What source of information did you consult, if any?)

7. Thinking back over a longer time period (the past 10 years), **what have been the biggest pest problems for wheat production in this area?**

8. What do you like most about your farm operation (wheat/cattle/crop rotations)? (Use index cards to list 2-3 things you like most.)

Figure 2. Focus group question route

III. Production Characteristics of Participating Wheat Producers

We asked participants a series of questions to determine the cost of production for their cropping systems in the 2002 crop year. These questions were designed to address the cost of production, and glean some additional demographic and cropping system information. Descriptive information that will assist in understanding some of the decision making can be developed from these questions. In addition to the tables presented here, we also asked about the use of crop insurance, lease rates and types, and USDA Farm Service Agency base acres on farms. Results are being analyzed and used in generating farm budgets, and will be reported upon completion.

Age of Growers. Participating growers were asked for their age at the time of the interview. All growers were willing to share this information with the interviewers. The growers in the study averaged four to eight years younger than the average farmer for their respective states (except in Nebraska, where the growers were nearly one year older than the state average). Based on the selection criteria and methods noted previously, it is not surprising that many of the managers willing to participate in this study were younger than the average for their state.

Table 8. Average age of participating producers in project by state and zone compared to state averages, 2002 cost-of-production interview

Project Zone	State	Number of Participants	Project Average Age	State* Average Age
1	Nebraska	14	53.4	52.5
1	Wyoming	14	49.6	54.4
1	N. Colorado	18	45.9	53.8
1	Zone total	46	49.2	53.1
2	S. Colorado	19	49.8	53.8
2	Texas	25	47.9	56.6
2	Zone total	44	48.7	56.2
3	Kansas	13	49.7	54.4
3	Oklahoma	42	49.6	55.1
3	Zone total	55	49.6	54.8
Project Total		145	49.2	55.3

* State averages from USDA, 1997 Census of Agriculture.

Project Acres. Producers in the project farm near 350,000 acres of dryland and irrigated land in six states. These producers are primarily dryland producers as noted by the nearly 9 to 1 ratio of dryland to irrigated land. In addition, there is a significant amount of both CRP land and pasture or rangeland on these farms. Many of the producers are involved in livestock operations to utilize feedstuffs grown on the farm as well as the acres of rangeland resources indicated.

Table 9. Acres and livestock for project growers by zone and state, 2002 cost-of-production interview

Project Zone	State	Dryland Acres	CRP Acres	Range-Pasture Acres	Irrigated Acres	Total Head Livestock
1	Nebraska	23,786	6,553	20,218	3,354	13,584
1	Wyoming	30,436	4,527	12,007	1,757	1,916
1	N. Colorado	79,914	12,287	23,689	2,389	3,646
1	Zone total	134,136	23,367	55,914	7,500	19,146
2	S. Colorado	71,789	22,188	34,764	7,822	4,588
2	Texas	42,808	3,588	33,523	27,444	6,837
2	Zone total	114,597	25,776	68,287	35,266	11,425
3	Kansas	23,065	995	6,152	2,265	2,537
3	Oklahoma	76,206	3,222	38,150	1,881	20,155
3	Zone total	99,271	4,217	44,302	4,146	22,692
Project Total		348,004	53,360	168,503	46,912	53,263

Winter Wheat Varieties. Project producers planted over 180,000 acres of winter wheat for harvest in 2002. There were 66 different varieties planted by these producers ranging from more than 39,000 acres of Jagger planted in Colorado, Kansas, Oklahoma, and Texas to 10 acres of Wahoo planted in Wyoming. Much of the Jagger is planted in the areas that may use wheat for grazing if conditions and prices merit the practice. Jagger is one of the premier varieties for forage production.

Russian wheat aphid resistance is important to growers in zones 2 and 3, thus a large number of acres of these varieties were planted for the 2002 crop. It will be interesting to compare these numbers with those from 2004 and 2005 crops with the recent discovery of Russian wheat aphid that does not seem to be affected by the present resistance. The most popular of the Russian wheat aphid resistant varieties was Prairie Red with 10,785 acres planted by participating growers. Halt followed closely behind with 9,803 acres planted by these producers for 2002 harvest. Additional acres were planted to Prowers 99 and Yumar.

In viewing figures reported in Table 10, it is important to keep in mind that we have the largest numbers of project participants in Colorado and Oklahoma. As a result, popular varieties grown in those states have both larger numbers of producers and acres planted among the participant group. (Please refer back to Table 7 and the section of the report describing project participants.)

Table 10. Most popular varieties of winter wheat planted by project participants, 2001-2002 crop production year (number of acres planted and number of producers by state for varieties over 500 acres).

State ===>	Colorado		Kansas		Nebraska		Oklahoma		Texas		Wyoming		Project Total	
Variety	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.
Jagger	400	2	6,990	12			28,861	36	2,874	6			39,125	56
Akron	15,444	15			285	1					1,700	3	17,429	19
Buckskin					1,913	5					11,184	11	13,097	16
Pioneer 2174			561	3			11,208	20					11,769	23
Prairie Red*	10,785	12											10,785	12
Pioneer 2137			1,759	6	669	1	4,489	10	3,266	6	300	1	10,483	24
Halt*	9,803	8											9,803	8
TAM 110	1,174	3							8,297	10			9,471	13
TAM 107	5,231	7							2,000	2			7,231	9
Lamar	3,990	7									1,100	1	5,090	8
Alliance	2,240	4			2,349	5					270	1	4,859	10
Prowers 99*	4,325	5											4,325	5
TAM 105									3,800	3			3,800	3
Triumph 64									2,824	2			2,824	2
T13	2,100	1											2,100	1
JagX7853							1,930	1					1,930	1
Coronado			946	3			912	3					1,858	6
Quantum	1,748	1			100	1							1,848	2
Yuma	1,780	3											1,780	3
Scout 66	640	1			500	1			500	1			1,640	3
Pioneer 2163			204	2			1,400	1					1,604	3
Trego	1,599	3											1,599	3
Longhorn			44	1			1,330	2	220	1			1,594	4
Yumar*	1,565	4											1,565	4
Pronghorn					1,130	5					180	1	1,310	6
Larned									1,200	1			1,200	1
TAM 200									1,055	4			1,055	4
OK 101							978	7					978	7
Custer							950	3					950	3
Early Triumph									800	1			800	1
Ogallala							250	1	521	2			771	3
TAM 302									660	2			660	2
HG9							608	1					608	1
Baca	603	1											603	1
Millineum					565	2					21	1	586	3
Above	530	4			28	1							558	5
Niobrara					543	1							543	1

* Russian wheat aphid resistant varieties.

Crop Rotations. As we observed earlier in Figure 1, some of our project participants clearly farm "wheat only" and others clearly farm crop rotations on all of their cultivated dryland wheat acres. Many others fall somewhere in-between for various reasons. In observing statistical summaries for these crop rotations, it is important to keep in mind that producers varied in the degree to which they adhere to a strict crop rotation. The data provides us with a general description of crop rotations among the study population. However, the acres in various rotations represent general approximations rather than definite statistical data points.

Since crop rotation is a central focus of the project, it will be important to carefully assess how area wheat producers are actually using crop rotation in their farming systems. Data from our first cost-of-production interview, in conjunction with grower comments in focus groups, will allow us to describe where producers' were in terms of crop rotations before initiation of the project. Subsequent interviews and more detailed statistical analyses of data will allow us to explore the issue further and also to observe any changes in production strategies.

As noted earlier in the report, we recorded a total of 92 different combinations of wheat, alternative crop, and fallow periods used in dryland cropping systems reported by the 141 interviewees. Figure 3 presents additional detail regarding the distribution of producers' acreage by separating the 92 different types of crop rotations into four categories in a 2 X 2 classification of systems: "wheat only" vs. "diversified" cropping systems and "continuously-cropped" vs. "fallow-interrupted" cropping sequences.

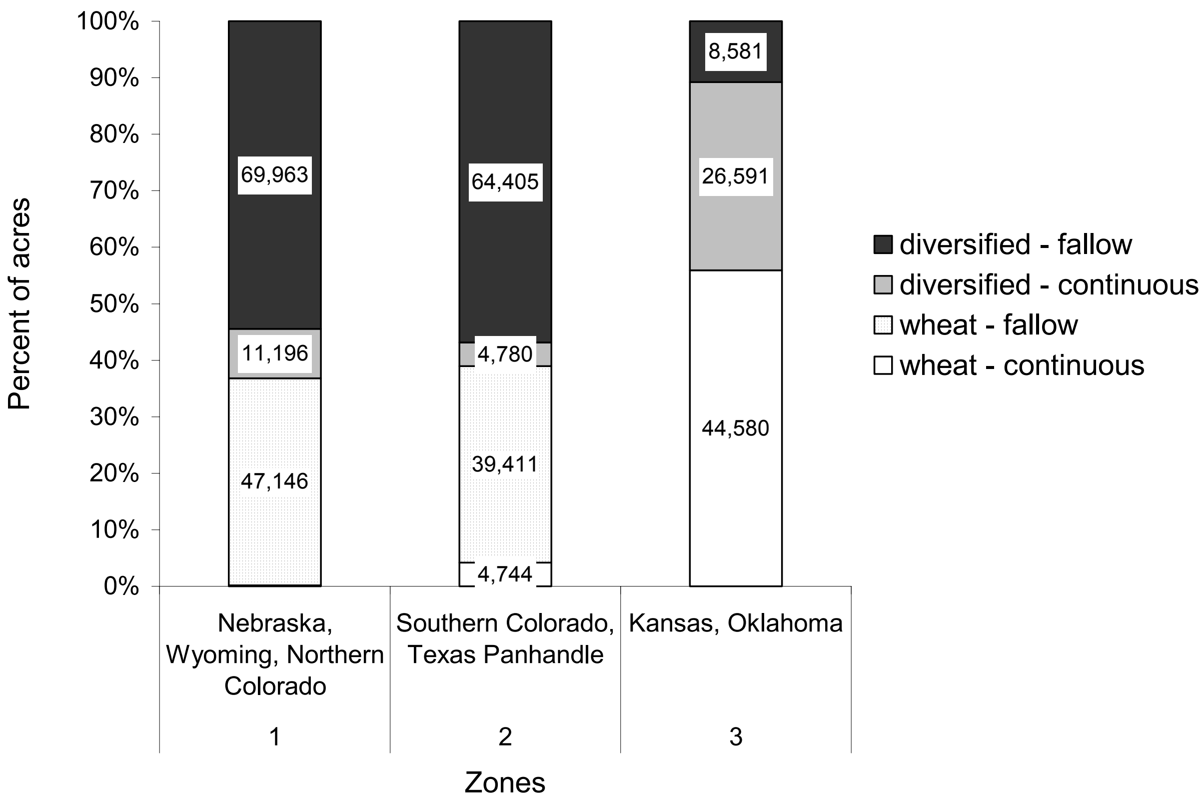


Figure 3. Acreage totals reported by producers in four categories of cropping systems comparing three regions of the project study area, 2002 cost-of-production interviews

Considering the two “wheat only” and “diversified” categories, out of a combined sum of 321,547 acres in dryland wheat systems reported by 141 interview respondents, 185,516 acres were farmed in a “diversified” system (one or more rotational crops grown between winter wheat and possibly fallow periods). The remaining 136,031 acres were in a “wheat only” system (either continuous wheat or a wheat-fallow-rotation). Considering the use of fallow periods versus continuous cropping, proportions in this graph reflect the prevalent use of fallow in Zones 1 and 2, and the contrasting tendency for continuous cropping in Zone 3 (Kansas and Oklahoma).

Producers in Zone 3 of the project area had the smallest proportion of collective acreage in diversified systems (about 40 percent of acreage in diversified systems as compared to over 60 percent among producers in the other two zones). However, Zone 3 producers had the greatest variation in different cropping combinations comprising these diversified systems, with 50 different combinations of cropping sequences (not shown in figure). This pattern reflects the relatively large proportion of acres in continuous wheat among Zone 3 producers.

Zone 2 producers had the least variation in types of rotation systems represented, with 18 combinations. The most common type of crop rotation in Zone 2 was wheat-sorghum-fallow, which accounted for 24 out of 43 rotational systems mentioned by producers in Zone 2.

Zone 1 producers indicated 35 rotation cropping combinations. As with Zone 2, the most common form of crop rotation was a wheat-alternate crop-fallow system, with 21 out of 68 responses representing this form. The most popular alternate crops in this system for Zone 1 were millet (15 responses), sunflower (8 responses), and corn (8 responses).

Also interesting in Figure 3 is the use of continuous diversified cropping among a few producers in Zones 1 and 2, areas in which producers customarily utilize a fallow period between crops. Among project participants in Zone 1, these systems involved years of sunflower and possibly a second summer crop—millet, corn, sorghum, oats—grown between years of winter wheat. In the Texas panhandle (Zone 2), a small number of producers were planting one or more years of sorghum, cotton, sunflowers, or corn between years of winter wheat. Over the course of the project we can observe the extent to which producers in these zones continue with continuous cropping systems.

Another important contrast for our project zones is the overall fewer acres collectively farmed by Zone 3 producers. This characteristic reflects the fact that Zone 3 producers tend to farm fewer acres at higher average yields compared to

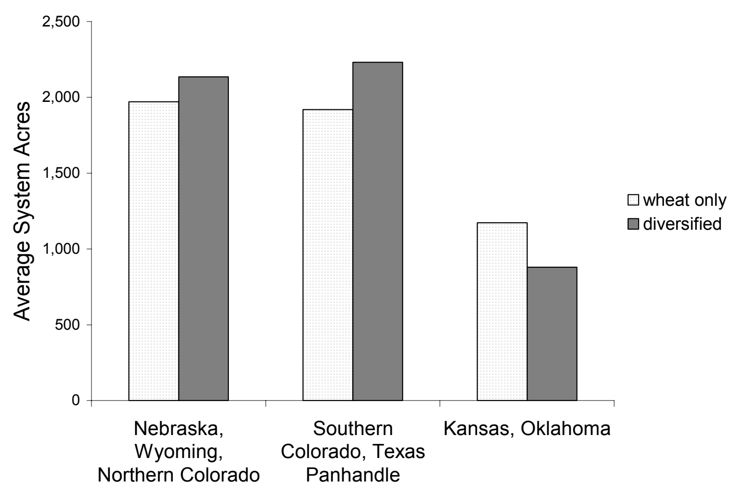


Figure 4 Average system acres in "wheat only" and "diversified" cropping systems comparing producers in the three project zones, 2002 cost-of-production interviews

producers in the other two zones. Figure illustrates this tendency for acreage farmed by our project participants in the three zones, comparing average acres in "wheat only" and "diversified" systems. This figure illustrates the tendency for higher average proportion of acres in continuous wheat compared to diversified systems among Zone 3 producers. We see the opposite tendency for the other two zones. Though the differences in the averages are small, this pattern was consistent with our expectation that rotational cropping in Zones 1 and 2 would be occurring in larger production systems while wheat-fallow may prevail in smaller systems. The small difference we observe in averages here is likely due to the relatively smaller number of "wheat only" producers among our participant group, and also the fact that a significant proportion of our participants utilize both wheat only and diversified cropping systems.

These details regarding crop production for our project participants provide important background information for interpreting subsequent reports, as well as baseline figures for evaluating production changes observed over the course of the project. A complete report of focus groups, combined with our farm budget reports will enable us to explore dimensions of producers' decision making in their use of these systems.

IV. Plans for Project Year 3 (2003-2004)

Our goals for the current project year are:

1. Complete a detailed focus group summary report, as a supplement to the current progress report. We plan to complete this report by January, 2004.
2. Complete enterprise and simulated total farm budgets for each producer. Reports will be given to producers prior to conducting second year interviews. Once budgets are generated, we can develop comparisons of cost effectiveness for different types of production systems utilized by the participant group and also evaluate changes in these systems observed during the project study period.
3. Conduct our second year cost-of-production interviews between December 2003 and March 2004.
4. Conduct additional analysis of interview data and focus groups for project educational materials, professional publications, and other forms of information dissemination.

Table 11. Project participation summary by focus group locations, 2003

			Focus groups		Interviews	
Group	**Location**	**Date**	**Invited**	**Attended**	**Planned**	**Completed**
01	Scottsbluff, NE	5-Mar	**10**	**5**	**5**	**5**
02	Scottsbluff, NE	5-Mar	**13**	**6**	**8**	**8**
03	Pine Bluffs, WY	6-Mar	**13**	**9**	**10**	**10**
04	Pine Bluffs, WY	6-Mar	**11**	**5**	**6**	**5**
05	Brush, CO	4-Mar	**11**	**10**	**11**	**10**
06	Brush, CO	4-Mar	**11**	**9**	**9**	**8**
Zone 1 Subtotal			**69**	**44**	**49**	**46**
07	Lamar, CO	12-Mar	**12**	**10**	**10**	**10**
08	Lamar, CO	12-Mar	**10**	**8**	**9**	**9**
09	Etter, TX	18-Feb	**9**	**5**	**7**	**7**
10	Perryton, TX	24-Feb	**5**	**3**	**6**	**4**
11	Umbarger, TX	20-Feb	**9**	**9**	**9**	**9**
12	Claude, TX	27-Feb	**9**	**4**	**5**	**5**
Zone 2 Subtotal			**54**	**39**	**46**	**44**
13	Hutchinson, KS	11-Feb	**9**	**8**	**8**	**8**
14	Hutchinson, KS	11-Feb	**8**	**5**	**5**	**5**
15	Blackwell, OK	30-Jan	**8**	**5**	**5**	**5**
16	Blackwell, OK	30-Jan	**8**	**7**	**7**	**7**
17	Cherokee, OK	31-Jan	**9**	**8**	**8**	**8**
18	Cherokee, OK	31-Jan	**9**	**9**	**9**	**9**
19	Altus, OK	28-Jan	**8**	**6**	**6**	**6**
20	Altus, OK	28-Jan	**8**	**7**	**7**	**7**
Zone 3 Subtotal			**67**	**55**	**55**	**55**
Total, All Zones			**190**	**138**	**150**	**145**

5. Status of Russian Wheat Aphid Resistance and Outline of a New AWPM Strategy

Prepared by Frank Peairs, Scott Haley, Jerry Johnson, Norm Elliott, and Dave Porter

Background. **Prairie Red** is a Russian wheat aphid resistant version of **TAM 107**, which was released by CSU in 1998. It has become a popular variety in parts of the state with consistent Russian wheat aphid problems. Resistance in this variety is conferred by the gene Dn4. Other varieties with this resistance gene include **Ankor, Halt, Prowers 99 and Yumar**. **Stanton**, a resistant variety released by Kansas State University in 2000, is thought to have a different gene. Combined, these varieties account for about one fourth of the wheat acres in Colorado in 2003.

Situation. Russian wheat aphid infestations in **Prairie Red** have been common this season in southeast and east central Colorado. Additional reports of infestations in other resistant varieties have been received from elsewhere in the state. Plants have been observed with heavy infestations and susceptible symptoms. In the past, plants occasionally had been observed with heavy infestations, but these plants always showed resistant symptoms.

Russian wheat aphids were collected from infested **Prairie Red** and placed on seedlings of resistant and susceptible varieties in the greenhouse. We observed a susceptible reaction on all varieties when we used aphids from infested Prairie Red, but we observed the expected resistant and susceptible reactions when we used aphids from our greenhouse colony (Table 1). Our initial conclusion is that there is a new strain (known as a "biotype") of Russian wheat aphid in Colorado that is virulent to **Stanton** and all CSU varieties containing Dn4. There are many questions that need to be answered about how this might have occurred and what needs to be done about it.

What we know

1. We have the original biotype (Biotype A) of the Russian wheat aphid in eastern Colorado and adjacent areas. This biotype has been observed this season in the field at Fort Collins and Hays, KS.

2. We have a new biotype (Biotype B) of the Russian wheat aphid. This is not a completely unexpected development, but there was no way to prepare for it because we could not identify which resistance sources to use in new varieties. We recently learned of a different biotype in Chile, and we had already taken some preliminary steps to prepare for its possible arrival. It is not known if the Chilean biotype also is Biotype B.

3. **Ankor, Halt**, **Prairie Red**, **Prowers 99**, **Stanton** and **Yumar** are effective against Biotype A and susceptible to Biotype B.

4. Biotype B infestations will need to be managed conventionally on all Colorado wheat varieties. This means that the crop will need to be scouted and treated with an insecticide if economic thresholds are exceeded.

5. Other management tactics such as biological control and cultural practices should be equally effective against both biotypes.

What we don't know

1. What sources of resistance can we use in future resistant varieties? There may be genes effective against both biotypes, or it may be necessary to develop varieties with a combination of genes effective against both biotypes. Our first test for Biotype B resistance is underway with over 20 different sources being tested. Several of these sources have already been used in crossing by the CSU wheat breeding program.

2. Are the two biotypes different only in their virulence to our resistant wheats, or are there other important biological or economic differences that might affect other management recommendations?

3. Where did Biotype B come from? It is possible that it adapted locally in response to the deployment of resistant varieties. The other possibility is that it is the result of a new introduction from another country. Many Russian wheat aphid biotypes are known to exist elsewhere in the world. Genetic studies by USDA-ARS at Stillwater, OK are underway in an effort to answer this question.

4. How do we tell the two biotypes apart? Currently we can collect aphids from damaged resistant varieties in the field and be fairly certain that we are collecting Biotype B. Also, we can collect from damaged susceptible plants and test aphids on resistant seedlings in the greenhouse. However, neither of these procedures provides the rapid and inexpensive answers we may need to make management decisions.

5. Will the distribution of Biotype B be different from that of Biotype A? We currently have very limited information on this subject. Information arising from the AWPM project will help answer this question.

Outline of a New Strategy for Russian wheat aphid Management.

Russian wheat aphid must be managed with a combination of management tactics if we are to minimize the development of future biotypes. The best management practices for the Russian wheat aphid in the future will involve new resistant wheat and barley varieties. However, future management systems must rely on a variety of pest management tactics, and not to rely solely on host plant resistance. This approach provides the best opportunity to effectively manage the pest and ensure the long-term durability of host plant resistance.

As part of the AWPM program we will enhance and update existing pest management tools, such as previously developed sampling methods and a computer based decision support system, and provide these tools to growers. We will take full advantage of the opportunities for education provided by the AWPM program to transfer these technologies to the grower community in the affected areas. In addition, we will use the opportunity to advance our knowledge of the ecology and management of the Russian wheat aphid to increase the effectiveness and scope of our pest management arsenal.

Growers Participating in Areawide IPM of the Russian Wheat Aphid and Greenbug (October 2002 – September 2003)

We wish to thank wheat producers involved with our project during the first year of implementation. Individuals marked with an asterik (*) are project cooperators, who allowed us to sample their fields.

COLORADO

Dave Anderson, Haxtun
Curtis Arbuthnot, Springfield
Brad Barth, Holly
James Brock, Wiley
Stan Cass, Briggsdale *
Jim Cooksey, Roggen
Steve Farnik, New Raymer
Jeff Farnik, New Raymer
Dave Harmon, Springfield
Jay Harryman, Merino
David Heck, Lamar
Mack Herndon, Springfield
Larry Hoozee, Snyden
Mike Hoppe, Sterling
Matt Johnson, Sterling
Curtis Lewton, Bennett
Jim Mertens, New Raymer
Mike Midcap, Wiggins
Stan Ramey, Fort Morgan
Todd Randolph, Walsh
Chris Rundell, Lamar *
Jeff Self, Springfield
Randy Shaw, Granada
Steve Shelton, Lamar
Greg Spitzer, Wiley
John Stulp, Lamar *
Terry Swanson, Walsh
David Wagers, Brush
Brad Warren, Keenesburg
Melvin Wessler, Springfield *
Monty Wessler, Springfield
Joseph Westhoff, Wiggins
Bryce White, Briggsdale *
Todd Wickstrom, Orchard
Richard Widener, Lamar
Bob Wilger, Bristol
Bob Wood, Springfield *

KANSAS

Robert Bacon, Hutchinson *
Jack Fountain, Arlington
Gregg Holcomb, Plevna
Ron Jacques, Hutchinson
Richard Krehbiel, Pretty Prairie
Terry Krehbiel, Pretty Prairie *
Laverne Miller, Partridge
Cameron Peirce, Hutchinson
Norman Roth, Sterling
Stan Stucky, Pretty Prairie
Layne White, Nickerson
Clark Woodworth, Sterling
Steve Yust, Sylvia

NEBRASKA

Kendall Atkins, Dix
Damon Birkhofer, Kimball
Bill Booker, Bushnell
Travis Cook, Kimball
Lane Darnall, Harrisburg
David Hagstrom, Kimball
Bryan Huffman, Potter
Alton Lerwick, Lyman *
David Lukassen, Kimball
Dave Petersen, Bayard
Wes Phillips, Bushnell
Kelly Sandberg, Gering *
Milton Sundin, Harrisburg *
Don Yung, Kimball

OKLAHOMA

Sunny Bode, Ames
Myron Bradt, Alva
Roy Brown, Okeene
Phil Cardwell, Lamont
Denis Carlson, Freedom
Joe Caughlin, Tonkawa *
Tom Coomes, Hollis
Roger Fischer, Frederick
Neil Goucher, Alva
Dean Graumann, Granite
Joe Hadwiger, Cherokee
Tim Hague, Cherokee
Jack Heatly, Mangum
Rodney Hern, Wakita
Mike Hogg, Granite
Bob Howard, Friendship *
John Inselman, Lucien
Travis Jantzen, Medford
Kent Kisling, Burlington *
Warren Little, Alva
Steve Littlefield, Cherokee *
Ralph Meade, Nardin
Matt Muller, Altus *
Jere Nelson, Hunter
Scott Neufeld, Fairview
Tom Nighswonger, Alva
Alan Nusser, Alva
R.J. Parrish, Hunter
Gary Peck, Hunter
Ivan Peck, Hunter
Corwin Petzold, Elmer
Rex Purdy, Tonkawa
Bryant Reeves, Willow
David Shepard, Helena
Brook Strader, Okeene
John Swihart, Gotebo
Buddy Treadwell, Frederick
Kent Walker, Frederick
Owen Westfahl, Okeene
Robert Williams, Gould
Bob Wright, Capron
Larry Young, Blackwell *

TEXAS

Jerry Broman, Hereford
Mike Brumley, Hereford
Eddie Bryan, Happy
Jim Burrell, Claude
Bob Byrd, Claude
Brent Clark, Dumas
David Cleavinger, Wildorado *
Randy Darnell, Ama
John Diedrichsen, Dumas
Jack Fields, Claude
Jim Fischbacker, Canyon
June Garner, Perryton
Andrew Gee, Hereford
H. Brooks Gunter, Claude
Kelly Hays, Dumas
Karl Johnson, Morse *
Daniel Krienke, Perryton
Billy Miller, Perryton

Texas (Cont'd)

David Moore, Dumas *
Gary Peterson, Canyon *
Donald Pshigoda, Perryton
Kevin Pshigoda, Perryton
Darren Stallwitz, Dumas
Greg Urbanczyk, Hereford
David Wagner, Vega
Willie Wieck, Dumas
Tommy Womack, Tulia *

WYOMING

Theron Anderson, Albin
Tim Anderson, Albin
Duane Aranci, Torrington
Lindsey Arnold, Hawk Springs
Stan Butler, Carpenter *
Jim House, Yoder
Louis Hubbs, Hawk Springs
Ivan Kranz, Carpenter
Albert Leo, Torrington
Larry Mullock, Yoder
Mike Peterson, Albin *
Chad Schaefer, Pine Bluffs
Jack Van Mark, Torrington
Boyd Yeik, Yode