Progress Report

Areawide IPM of the Russian Wheat Aphid and Greenbug

A Summary of Program Activities During the Second Year of Phase II
(October 2003 - September 2004)

(Submitted January 3, 2005)

Executive Summary

This report includes demonstration, evaluation, and research activities of the AWPM of the Russian wheat aphid and Greenbug project for the second year of Phase II (October 1, 2003 – September 30, 2004). During this time period we made substantial progress towards completing project objectives. This progress report does not include information on organizational meetings and related activities. However, as was the case last year, 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 various demonstration and evaluation activities is in progress, and this report reflects more integration of various project outcomes than last year's report.

Some significant AWPM activities and observations during the reporting period are highlighted below, while many more are outlined in the full report:

1) Greenbug populations were sporadic in the suppression area during the 2003-2004 growing season. Some areas, such as southwestern Oklahoma and the Texas Panhandle had economic infestations, while other areas did not. There was no clear evidence for differences in greenbug infestation levels or natural enemy populations among diversified or traditional wheat only production systems. However, there was some evidence for lower greenbug infestations in diversified systems, probably because planting dates for wheat in diversified systems are later than in dual purpose wheat systems, thus reducing the length of the autumn colonization period by greenbugs. In Colorado where the Russian wheat aphid is the major pest, Russian wheat aphid densities were over double for the traditional growers compared to the diversified growers.

2) The new strain of Russian wheat aphid, which damages previously resistant winter wheat varieties, was monitored in AWPM demonstration zones 1 and 2. An important and originally unanticipated objective of the AWPM project is to determine the geographic extent and economic impact of the new strain, and to assess existing sources of resistance against the new strain. Results of surveys indicate that the distribution of the new biotype in Colorado is patchy. There are some areas of the state where the new biotype comprises nearly 100% of the Russian wheat aphids in wheat and others where it makes up a minor fraction of the population. Results thus far suggest that the new biotype is not displacing the original biotype, but is moving towards co-dominance.

3) Socioeconomic evaluation accomplishments were numerous and varied. We interviewed 145 growers during 2003-2004 relative to management practices, and other information to help evaluate diversified and traditional wheat production systems. A very important benchmark of success for the project was reached in that growers have increased the use of greenbug and Russian wheat aphid resistant wheat cultivars by 15% and 65%, respectively since the start of the AWPM project.

We added a series of questions to the interviews regarding growers' wheat production and pest management practices, including wheat seed cleaning, seed treatment, field record keeping, insect scouting, and observations of beneficial insects. We found the following: a) treatment insecticides or fungicides for wheat were not widely utilized by the growers and are generally considered cost prohibitive; b) soil testing at some regular interval is common among growers; c) nearly all growers keep some type of field records, the most common type of record keeping was a journal, day planner, or calendar where field operations are recorded; d) 106 out of 145 growers indicated that they use a computer for some or all of their farm record keeping; e) the majority of growers practice limited tillage on some or all of their cultivated acres; f) 34 out

of 145 growers were practicing no-till on some or all of their crop acres; g) we have no-till growers distributed throughout the project study region, with larger numbers in Colorado and Oklahoma due to larger numbers of project participants in those states. The importance of these findings to the AWPM project lies in how it will help us develop and target pest management programs.

4) Important research and development progress included: a) development and deployment an Oracle© on-line database application for entering project field pest survey data. The purpose of the database is to ensure that all data from the project are accessible for project-wide analysis and evaluation. The database application also has potential for use as a region-wide pest alert system; b) continuation field scale tests using multi-spectral and hyper-spectral remote sensing to detect greenbug and Russian wheat aphid infestations. Results are detailed in the report and are highly promising relative the potential for developing and using this tool in operational pest management programs; c) the first year of field scale studies to determine the dynamics of aphid natural enemies in diversified compared to wheat or sorghum only cropping systems was completed. Results are complex and reveal highly intricate relationships among natural enemy communities in diversified cropping systems.

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1. Field Demonstration Site Summaries

a. Colorado demonstration sites

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Introduction

Three counties, Baca, Prowers, and Weld, each with a conventional and diversified grower, were sampled for the 2003-2004 Colorado AWPM season. Figure 1 shows the counties in Colorado, with the AWPM counties circled in red, and Table 1 describes the county, rotation, and grower. In addition to the W-M-F rotation for Stan Grower #55, sunflower was sampled. The sunflower is part of a W-W-S-C-Sunf.-F rotation and was included as an additional sampling of interest.

Sampling commenced in late August and continued until October, 2004. The fields were mapped with GPS coordinates using an HP IPAQ 2215 Pocket PC. Soil samples were taken prior to planting for an assessment of soil fertility and available soil water. Wheat fields were sampled for volunteer wheat and weeds before planting, and then sampled for pests, natural enemies, and weeds following planting. For sorghum, sunflower, and millet, pests and natural enemies were sampled. Weather stations were set up adjacent to all field sites to measure temperature and precipitation. Sampling was discontinued for grower #50's wheat on May 20, 2004 due to crop failure. The results of this season are organized by county and crop.

Table 1. Counties, rotations, and growers for the 2003-2004 Colorado growing season, AWPM.

County	Rotation	Cooperator
Baca	W-F	Grower #52
Baca	W-Sunf.-F	Grower #53
Prowers	W-F	Grower #51
Prowers	W-S-F	Grower #50
Weld	W-F	Grower #283
Weld	W-M-F	Grower #55

Materials and Methods

Soil Sampling

Each field (both wheat and alternative crops) was divided up into four benchmark areas, which represented the major variation in soil conditions (i.e. soil type/slope) in the field. At these benchmarks, 0-4 inch soil samples are taken prior to planting and analyzed for pH, organic matter, N, P, K, and Zn. Also, a hydraulic soil sampler was used to sample available soil water in one-foot increments down to six feet.

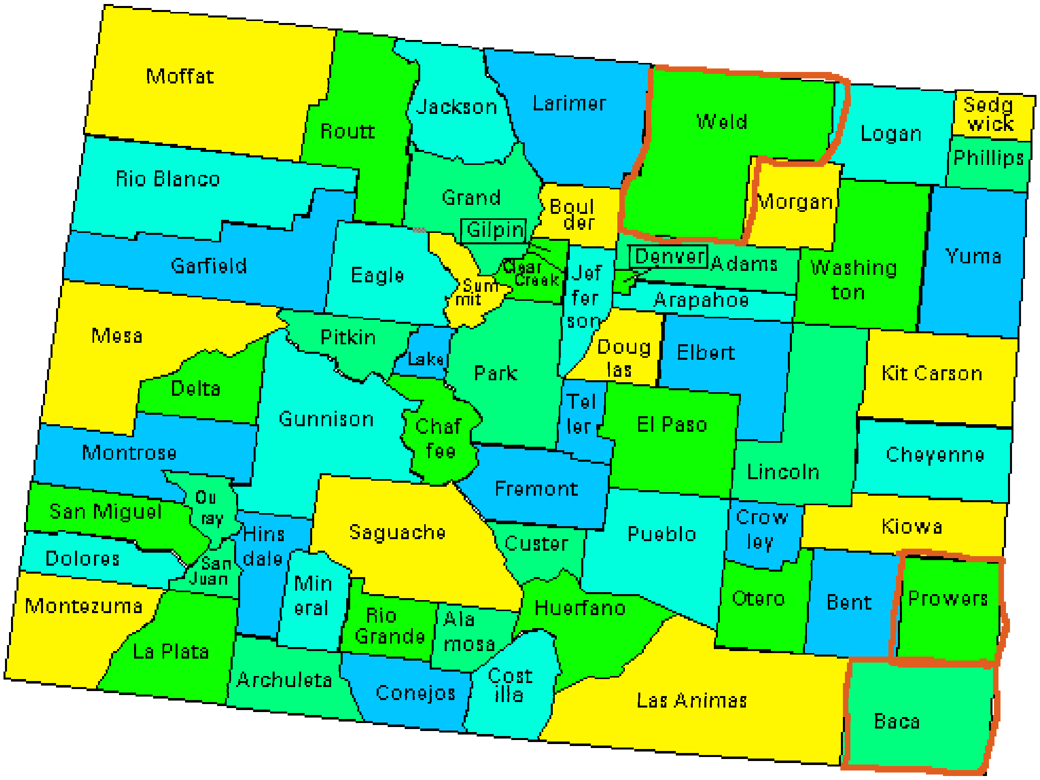

Figure 1. Colorado counties. AWPM counties are circled in red.

Wheat

Wheat fields were divided into a grid of 25 uniformly sized cells, distributed to provide good coverage of the field. Winter wheat sampling began two weeks before planting and continued until two weeks following harvest. Sampling was conducted for aphids, parasitoids, natural enemies, and other pests. Aphids were sampled once in October and again in the spring. Twenty-five one-foot rows were taken once per month at each site and extracted using Berlese funnels. Aphids were also sampled by collecting four tillers at each of the 25 points biweekly. Predators were sampled visually in a two-row foot area biweekly, and, when the wheat was tall enough, 25 sweep net samples were taken along with the visual sample at each point. Weeds were also sampled at the same 25 grid sampling points in the field as for insects. In addition, the field border area was surveyed for the presence or absence of grasses serving as aphid hosts. Once in October or November, a wheat sample was taken to identify the presence of wheat curl mites. The Hessian fly is not a potential pest in Colorado, thus sampling was not necessary. In spring, the number of sawflies in the routine sweepnet samples for predators was counted, and, if populations of adults were seen during boot through early heading, a 100-tiller sample was taken from across the field to determine the larval infestation level. Significant disease incidence would likely be low, but diseases would be reported if found. Surveys and coinciding survey times are displayed below in Table 2.

Table 2. Surveys and survey times for sampling in winter wheat.

Surveys	**Survey Times**
In-field weed sampling	Pre-plant, post-plant, 0-14 days before jointing, 0-14 days before harvest, 0-14 days after harvest
Field border weed sampling	Pre-plant, 0-14 days after harvest
Volunteer wheat (for aphids and mites)	Pre-plant
Berleses (aphid counts)	Post-plant, 1x/month in spring
Aphid tiller	Post-plant, biweekly in spring
2-row foot predator	Post-plant, biweekly in spring
Predator sweeps	Biweekly in spring (when wheat is tall enough)

Sorghum

In sorghum, monitoring was conducted during the following times: late whorl, flowering, and grain fill, starting in early August. If aphid populations were to become significant, sampling would be conducted more frequently. Data collection consisted of samples to determine aphid and beneficial insect abundance and samples taken once during flowering through grain filling for headworm infestations. Sampling with the IPAQ handheld computer was accomplished at 10 locations, which were chosen to give good coverage of the field. At each of the 10 locations, 50 plants were visually sampled for beneficial insects. For aphids, three plant samples were taken at each location (beginning, middle, and end of the row) to estimate aphid abundance. Each plant was cut off at the soil level. Aphids were counted inside the individual leaves and whorl of the plants. The infestation level of banks grass mite should be determined each time the field is sampled. Headworm samples are taken only one time during the sorghum growing season, after flowering.

Sunflower

Sunflower sampling was undertaken at four benchmark areas using several methods, and sampling commenced early August. Seed weevils were counted per head on 15 heads chosen at random in each of the benchmarks. Counting started at late bud stage (R-4.0) and stopped when the majority of the plants had passed 70% pollen shed (R-5.7). Also, the head clipper weevil was surveyed, counting the number of cut plants in 50 row foot in each of the four benchmark areas. The head moth was surveyed two weeks after plants reach the 5.9 stage. Heads were removed from 15 plants chosen at random from the four benchmark areas. Sunflower stem weevils and stem borers were counted at plant maturity. Fifteen stalks were randomly chosen at each of the four benchmark areas, the stalks were split, and the number of weevil and stem borer larvae were counted.

Millet

One sampling to determine the presence of cereal aphids and possible natural enemies was done in late summer (late August). Twenty-five one-foot row plant samples were randomly taken throughout the field to determine insect and mite density, extracted with Berlese funnels. Predators were sampled by visually inspecting 25 one-foot rows across the field.

Weather

Weather stations were stationed near benchmark areas at each field site. Temperature and rainfall were measured every 15 minutes, downloaded at least once a month, and recorded for each cooperator.

Results

Baca County-Grower #52 (W-F) and #53 (W-Sunf.-F)

Aphids

Aphids were sampled once in October and again from February through June. Table 3 shows *D. noxia*, *S. graminum, R. padi*, and *R. maidis* densities for each grower. *Rhopalosiphum maidis* was present in October following planting for both cooperators, and a few *R. maidis* were sampled in February. *Rhopalosipum padi* was present at both sites in October, increased in February, and declined later in the spring. In March, *S. graminum* was the most abundant aphid at both sites. *Diuraphis noxia* densities increased for Grower #53 and Grower #52 in April and again substantially in May and June. Total aphid densities were higher at Grower #52's site at each sampling date with densities at least doubling those at Grower #53's site.

Table 3. Aphids for Baca County cooperators, Grower #52 and Grower #53, in wheat. Total # aphids=sum of aphids for 25, 1-ft rows, extracted by Berlese funnels.

Date	Aphid		Grower #52	Grower #53
15 October 2003 (Post-Planting)	*D. noxia*		0	0
	S. graminum		19	1
	R. padi		3	1
	R. maidis		82	5
		Total	**104**	**7**
25 February 2004	*D. noxia*		9	5
	S. graminum		9	10
	R. padi		55	16
	R. maidis		10	16
		Total	**83**	**47**
17 March 2004	*D. noxia*		4	1
	S. graminum		37	5
	R. padi		4	0
	R. maidis		1	1
		Total	**46**	**7**
16 April 2004	*D. noxia*		56	6
	S. graminum		5	3
	R. padi		1	2
	R. maidis		0	0
		Total	**62**	**11**
20 May 2004	*D. noxia*		553	161
	S. graminum		7	3
	R. padi		0	1
	R. maidis		0	0
		Total	**560**	**165**
17 June 2004	*D. noxia*		2656	1041
	S. graminum		0	0
	R. padi		0	2
	R. maidis		0	0
		Total	**2656**	**1043**

Aphid densities from biweekly tiller sampling are displayed in Table 4. *Diuraphis noxia* peaked on June 3, 2004 for both cooperators. Both *D. noxia* and *S. graminum* populations were highest at each date for Grower #52, which mimicked the densities retrieved from Berlese extractions.

Table 4. Total aphids per 100 tillers collected biweekly for each cooperator.

	S. graminum		*D. noxia*	
	Grower #52	*Grower #53*	*Grower #52*	*Grower #53*
17 March 2004	7	4	0	0
2 April 2004	29	2	20	3
16 April 2004	0	0	0	0
7 May 2004	0	0	22	5
20 May 2004	0	0	119	31
3 June 2004	19	0	1753	631
17 June 2004	0	0	1	0

Predators

For the diversified and conventional farmers, natural enemies were prevalent in wheat. Table 5 shows the major predators present in wheat from May 20 through June 16, 2004. Natural enemy densities were relatively consistent between cooperators. The most abundant natural enemy for both cooperators was the spider, which was prevalent at all sweepnet sampling dates. Coccinellids and nabids were also abundant. Grower #52 had a greater density of the minute pirate bug, *Orius* sp. Lacewings and immature coccinellids were present but at low densities, which was also true for the immature coccinellids. Wheat stem sawflies were not found in any of the sweepnet samples. Also, no parasitoids were found in any of the infested wheat tillers that were placed in the emergence canisters. Predator densities from visual biweekly samples included spiders, coccinellids, and minute pirate bugs for both cooperators.

Table 5. Predators in wheat for Grower #52 and Grower #53. Each date represents a total for 625 sweepnet samples per site (at 25 points).

	Nabidae		**Spiders (Aranae)**		**Coccinellidae**		**Coccinellidae (imm.)**		**Lacewing (Chrysopidae)**		**Minute Pirate Bug**	
Date	*Grower #52*	*Grower #53*	*Grower #52*	*Grower #53*	*Grower #52*	*Grower #53*	*Grower #52*	*Grower #53*	*Grower #52*	*Grower #53*	*Grower #52*	*Grower #53*
20 May 2004	29	17	178	195	28	12	1	0	1	2	22	5
3 June 2004	1	25	36	59	9	19	0	0	1	0	3	0
16 June 2004	5	9	37	32	7	3	0	0	1	1	5	0

Other Pests

In addition to aphids, two pests commonly found in Colorado AWPM sites are the brown wheat mite and cutworm. Table 6 shows cutworm and brown wheat mite densities for February through April. Brown wheat mite populations were present at both sites, with densities peaking on April 2. Populations declined following the last April sampling. Cutworms were also present March through April, biweekly, in low densities. Wheat curl mites were also sampled but were not abundant in late October/early November at any of the sites.

Table 6. Other pests present during biweekly 2-row foot predator samples at both Grower #52 and Grower #53 sites.

	Brown wheat mite		Army cutworm	
	Grower #52	*Grower #53*	*Grower #52*	*Grower #53*
25 February 2004	0	21	0	0
17 March 2004	105	0	0	3
2 April 2004	121	109	0	4
16 April 2004	28	2	1	4

Weeds

Prior to planting, jointed goatgrass and *Bromus* sp. were present along the borders at both sites but in very low densities. Following planting, bindweed densities were high on June 17, 2004, two weeks prior to harvest, and lambsquarter densities were high on July 12, 2004, two weeks following harvest, for Grower #52. Grower #53 followed a similar weed density (same species) on the same dates in addition to a high density of pigweed on July 12. Kochia, and Russian thistle densities were very high on July 12 for both cooperators.

Sunflower

Sunflowers were sampled August through September for seed weevils, heaclipper weevils, sunflower head moths, stem weevils, and stem borers (Table 7). Seed and headclipper weevils were sampled on August 11 and 26, and densities were very low. Headmoth larvae were sampled on August 26, with few larvae present in the 60 heads sampled. Stem weevils and borers were sampled in October.

Table 7. Insects sampled for sunflower for Grower #53 in 2004, totaled over 60 sunflower plants at each date.

	Seed weevil	**Headclipper weevil**	**Sunflower head moth**	**Stem weevil**	**Stem borer**
11 August 2004	2	0	0	0	0
26 August 2004	0	0	24	0	0
27 October 2004	0	0	0	1	6

Prowers County-Grower #51 (W-F) and Grower #50 (W-Sorghum-F)

Wheat

Aphids

Aphids were sampled in October, following planting, and again in February through June. Table 8 shows *D. noxia*, *R. padi*, and *S. graminum* and their densities for each grower. For Grower #51, *R. maidis* was the most abundant aphid in October, and *D. noxia*, *S. graminum*, and *R. padi* were also present. *Diuraphis noxia* and *S. graminum* were present in March and April, and *D. noxia* was the dominant aphid in May and June. In Grower #50's field, *D. noxia* was present in March and April, and *S. graminum* was also present in April. Because Grower #50's wheat failed, it is difficult to compare aphid densities between cooperators.

Table 8. Aphids for Prowers cooperators, Grower #51 and Grower #50, in wheat. Total # aphids=sum of aphids for 25, 1-ft rows, extracted by Berlese funnels. **=crop failure, no sampling.

Date	Aphid	Grower #51	Grower #50
15 October 2003 (Post-Planting)	*D. noxia*	2	0
	S. graminum	6	0
	R. padi	3	0
	R. maidis	52	0
	Total	**63**	**0**
8 March 2004	*D. noxia*	0	13
	S. graminum	0	0
	R. padi	0	0
	R. maidis	0	0
	Total	**0**	**13**
15 April 2004	*D. noxia*	16	42
	S. graminum	23	7
	R. padi	5	1
	R. maidis	0	0
	Total	**44**	**50**
20 May 2004	*D. noxia*	606	**
	S. graminum	1	**
	R. padi	0	**
	R. maidis	0	**
	Total	**607**	
16 June 2004	*D. noxia*	518	**
	S. graminum	0	**
	R. padi	5	**
	R. maidis	0	**
	Total	**523**	

Aphids densities from biweekly tiller sampling are displayed in Table 9. Both *S. graminum* and *D. noxia* were present at all biweekly sampling dates in the spring, with the exception of March 16. Aphid densities were low for both species.

Table 9. Total aphids per 100 tillers collected biweekly at each date for each cooperator. **=crop failure, no sampling.

	S. graminum		*D. noxia*	
	Grower #51	*Grower #50*	*Grower #51*	*Grower #50*
16 March 2004	0	0	0	0
31 March 2004	5	0	5	0
15 April 2004	0	26	0	11
5 May 2004	0	6	0	5
20 May 2004	1	0	1	0
3 June 2004	0	**	0	**
16 June 2004	0	**	0	**

Predators

There were no apparent differences in natural enemy densities between cooperators. Table 10 shows the major predators for wheat from May 20 through June 16, 2004. Spider densities were high in late May for Grower #51 and Grower #50. Coccinellids increased the beginning of June. Lacewings, nabids and minute pirate bug populations were present but at very low densities. Predator densities from visual biweekly samples included spiders, coccinellids, and minute pirate bugs for both cooperators at minimal densities.

Table 10. Predators in wheat for Grower #51 and Grower #50. Each date represents a total of 625 sweepnet samples per site (at 25 points). **=crop failure, no sampling.

	Nabidae		**Spiders (Aranae)**		**Coccinellidae**		**Coccinellidae (imm.)**		**Lacewing (Chrysopidae)**		**Minute Pirate Bug**	
Date	*Grower #51*	*Grower #50*	*Grower #51*	*Grower #50*	*Grower #51*	*Grower #50*	*Grower #51*	*Grower #50*	*Grower #51*	*Grower #50*	*Grower #51*	*Grower #50*
20 May 2004	13	1	80	63	57	5	7	0	5	0	9	0
3 June 2004	12	**	79	**	141	**	15	**	3	**	3	**
16 June 2004	0	**	6	**	12	**	12	**	2	**	0	**

Other Pests

Table 11 presents the density of brown wheat mites and army cutworms present in biweekly samples March 16 through May 5, 2004. Brown wheat mite populations were high for both cooperators for March through April 15, 2004, especially for Grower #51. Densities of brown wheat mite peaked on March 31 at Grower #51's field at 2886 mites and similarly for Grower #50 at 1467. Populations declined following the last April sampling. Army cutworms were found at both sites April 15 and May 5, but densities were minimal.

Table 11. Other pests present during biweekly 2-row foot predator samples at both Grower #51 and Grower #50 sites, March 16-May 25, 2004.

	Brown wheat mites		Army cutworms	
	Grower #51	*Grower #50*	*Grower #51*	*Grower #50*
16 March 2004	1155	1467	0	0
31 March 2004	2886	818	0	0
15 April 2004	812	22	5	12
5 May 2004	0	0	3	7

Weeds

Weed field borders did not contain any grasses of significance for either cooperator prior to planting. For Grower #51, crested wheatgrass densities were high within the field two weeks prior to harvest. Bindweed was also present at this time but was minimal. Following harvest, lambsquarter was abundant within Grower #51's field, and grasses were not present along the field borders. Within-field weed sampling was not conducted for Grower #50 two weeks before or after harvest nor was the field border sampled for grasses following harvest due to the crop failure. Kochia and Russian thistle were very dense after harvest for both sites.

Sorghum

Sorghum was sampled three times at Grower #50's site, and Table 12 below displays predator and pest densities for the 10 benchmark areas sampled. *Rhopalosiphum maidis*, was the most abundant aphid, with densities peaking at 1300 at the late whorl stage. *Schizaphis graminum* was not present during the three sampling periods. Coccinellids and minute pirate bugs were the most abundant predators. Spiders, nabids, and lacewings were present, but their densities were minimal. Banks grass mite was not present. Sandburs were very dense in late August through October in the field.

Table 12. Predators and pests of sorghum at Grower #50's field during late whorl, flowering, and grainfill. Data represent predator totals of 10 benchmark areas for each date.

		R. maidis	Nabidae	Spider (Aranae)	Coccinellidae	Lacewing (Chrysoptera)	Minute Pirate Bug
Late Whorl	16 August 2004	1300	2	5	44	0	4
Flowering	8 September 2004	1194	0	0	9	5	29
Grainfill	27 October 2004	414	0	0	4	0	0

Weld County-Grower #283 (W-F) and Grower #55 (W-Millet-F and Sunflower)

Wheat

Aphids

Aphids were sampled once in October and again from March through June. Table 13 shows *D. noxia*, *R. padi*, and *S. graminum* and their densities for each grower. *Rhopalosiphum maidis* was present at Grower #283's site in October, and *D. noxia* was present at both sites in April. *Schizaphis graminum* was present for both cooperators in April, and densities increased in June for Grower #55. *Diuraphis noxia* densities increased significantly from May to June and remained high in July for both sites.

Table 14 shows the number of aphids per 100 tillers at each sampling date. *Diuraphis noxia* was consistently found in the 100 tillers from April through July.

Table 13. Aphids for Weld County cooperators, Grower #283 and Grower #55, in wheat. Total # aphids=sum of aphids for 25, 1-ft rows, extracted by Berlese funnels.

Date	**Aphid**		**Grower #283**	**Grower #55**
21 October 2003 (Post-Planting)	*D. noxia*		0	0
	S. graminum		0	0
	R. padi		0	0
	R. maidis		7	0
		Total	**7**	**0**
12 March 2004	*D. noxia*		0	1
	S. graminum		0	0
	R. padi		0	0
		Total	**0**	**1**
5 April 2004	*D. noxia*		15	3
	S. graminum		2	0
	R. padi		0	0
		Total	**17**	**3**
3 May 2004	*D. noxia*		46	16
	S. graminum		4	1
	R. padi		0	0
		Total	**50**	**17**
1 June 2004	*D. noxia*		1325	430
	S. graminum		0	66
	R. padi		0	7
		Total	**1325**	**503**
8 July 2004	*D. noxia*		1147	884
	S. graminum		0	0
	R. padi		0	0
		Total	**1147**	**884**

Table 14. Total aphids per 100 tillers collected biweekly at each date for each cooperator. **=no sample due to rain.

	S. graminum		*D. noxia*	
	Grower #283	Grower #55	Grower #283	Grower #55
12 March 2004	0	0	0	0
23 March 2004	0	0	0	0
8 April 2004	0	0	0	0
20 April 2004	0	0	80	**
3 May 2004	0	0	10	1
21 May 2004	0	0	24	4
1 June 2004	0	0	41	0
15 June 2004	0	0	133	21
8 July 2004	0	0	11	10

Predators

Table 15 shows the major predators for wheat from May 21 through July 8, 2004. The minute pirate bug was abundant on May 21 through June 1 for both cooperators, with densities at Grower #283's site doubling those of Grower#55's. When populations of minute pirate bugs decreased in mid June, coccinellids (adult and immature), nabids, and spiders were present. Grower #55 spider densities were double those of Grower #283 at each sampling date. Grower #283 had a greater density of immature and mature coccinellids from May through July. Lacewings were present in low densities at both sites. Predator densities from visual biweekly samples included spiders, and minute pirate bugs, carabids, and big eyed bugs, *Geocoris* sp., for both cooperators.

Table 15. Predators in wheat for Grower #283 and Grower #55. Each date represents a total for 625 sweep net samples per site (at 25 points).

	Nabidae		**Spiders (Aranae)**		**Coccinellidae**		**Coccinellidae (imm.)**		**Lacewing (Chrysopidae)**		**Minute Pirate Bug**	
Date	*Grower #283*	*Grower #55*	*Grower #283*	*Grower #55*	*Grower #283*	*Grower #55*	*Grower #283*	*Grower #55*	*Grower #283*	*Grower #55*	*Grower #283*	*Grower #55*
21 May 2004	28	51	20	67	10	7	1	0	2	1	714	309
1 June 2004	4	18	15	62	3	8	0	0	0	0	48	198
15 June 2004	38	34	25	57	59	10	77	1	4	2	35	30
8 July 2004	45	31	37	90	76	40	95	15	1	0	15	3

Other Pests

Table 16 presents the density of brown wheat mite and army cutworms present in biweekly samples March 12 through April 20, 2004. Brown wheat mites were present at both sites through March 23. Populations declined following the last April sampling. Cutworms were also abundant March through April, biweekly, at both sites.

Table 16. Other pests present during biweekly 2-row foot predator samples at both Grower #283 and Grower #55 sites March 16-May 25, 2004. **=no sample due to rain.

	Brown wheat mite		Army cutworm	
	Grower #283	*Grower #55*	*Grower #283*	*Grower #55*
12 March 2004	0	87	0	0
23 March 2004	80	64	0	0
8 April 2004	0	0	0	0
20 April 2004	0	**	0	**

Weeds

Before planting, jointed goatgrass, volunteer wheat, and *Bromus* sp. were present around Grower #283's field border, but their presence was minimal. *Bromus* sp. grasses were also present around Grower #55's field before planting but were minimal. For Grower #283, bindweed densities were moderate two weeks before and after harvest within the field, and pigweed was present before harvest. Crabgrass was dense in Grower #55's field two weeks before harvest. Field borders contained crested wheatgrass and *Bromus* sp. at low densities at both sites following harvest.

Millet

Millet was sampled once on September 1, 2004. After extracting 25, one-foot rows, with Berlese funnels, no aphids, mites, or other pests were present. After visual analysis of predators, five spiders were present in a total of 25, one-foot row predator checks.

Sunflower

Sunflowers were sampled August through September for seed weevils, heaclipper weevils, sunflower head moths, stem weevils, and stem borers (Table 17). Seed and headclipper weevils were sampled on August 10 and 16, and densities were very low. Headmoth larvae were sampled on September 1, with very few larvae present in the 60 heads sampled. Stem weevils and borers were sampled on September 28, and a significant number of stem weevils were present in the stems. Borers were also present at this time.

Table 17. Insects sampled for sunflower for Grower #53 for 2004 totaled over 60 sunflower plants.

	Seed weevils	Headclipper weevil	Sunflower head moth	Stem weevil	Stem borer
10 August 2004	9	6	0	0	0
16 August 2004	5	4	0	0	0
1 September 2004	0	0	2	0	0
28 September 2004	0	0	0	532	23

Weather

Table 18. Precipitation (in.) data for Sept. 2003-Sept. 2004 for all cooperators.

	Grower #283 (Briggsdale)	Grower #55 (Briggsdale)	Grower #53 (Springfield)	Grower #52 (Springfield)	Grower #51 (Lamar)	Grower #50 (Lamar)
September 2003	0.84	0.39	0.10	0.08	0.95	1.08
October 2003	0.00	0.00	0.00	0.00	0.00	0.00
November 2003	0.00	0.00	0.00	0.00	0.00	0.00
December 2003	0.02	0.00	0.00	0.06	0.00	0.00
January 2004	0.04	0.00	0.00	0.00	0.00	0.00
February 2004	0.00	0.02	0.00	0.00	0.01	0.50
March 2004	0.00	0.04	0.26	0.00	0.40	0.42
April 2004	0.00	0.00	3.67	0.00	3.33	0.72
May 2004	0.00	2.39	0.03	0.00	0.24	0.01
June 2004	1.39	1.78	5.81	0.00	3.44	4.32
July 2004	0.14	0.57	3.21	1.17	1.79	0.85
August 2004	0.59	0.60	3.72	0.00	0.09	0.82
September 2004	0.51	0.82	0.22	0.00	0.00	1.71
Sept-Sept	**3.53**	**6.61**	**17.02**	**1.31**	**10.25**	**10.43**

Summary

For wheat, several observations were made for the 2003-2004 season. There was an abundance of aphids for all cooperators, but Baca Co., in particular. Because of the new *D. noxia* biotype, it was interesting to observe an increase in aphid densities in comparison to the 2002-2003 season. At Grower #52's, the wheat was stunted and tillers were symptomatic. Aphid densities were over double those of Grower #53's, the diverse grower, at each date sampled. In Prowers Co., aphid densities were moderate for Grower #51's W-F rotation. For Grower #50, the wheat failed on May 20, making it difficult to compare aphid populations between growers. Weld Co. mimicked the results for Baca Co., with the W-F grower, Grower #283, maintaining at least double the *D. noxia* densities of Grower #55. Brown wheat mite densities were extremely high in Prowers Co. from March 16 through April 15 for both cooperators but for Grower #51 (W-F), in particular. Other pests, including cutworms, wheat curl mites, and wheat stem sawfly populations, were minimal. Predator populations were relatively consistent between diverse and conventional growers within each county. Weeds and alternative host grasses did not play a significant role within the field or along the field borders at any of the sites. Kochia and Russian thistle dominated the fields following harvest in all counties, which was most likely due to late season precipitation.

For the alternative crops, in Baca Co., sunflowers at Grower #53's had very few pests. Seed weevils, sunflower head moths, and stem weevils and borers were present but minimally. In Prowers Co., Grower #50's sorghum contained several *R. maidis*, low densities of predators, and no mite infestations. The field was infested with sandburs for flowering and grainfill samplings. In Weld Co., millet did not contain any pests and very few predators. The millet suffered from drought stress and appeared stunted. The sunflower benchmarks had seed and headclipper weevils, sunflower head moths, and stem weevils and borers. All insects were minimal, with the exception of stem weevils, which averaged about eight per stalk. The stems did not show a high percentage of damage. However, the sunflowers were stunted and lacked vigor early in the growing season, which is most likely due to drought conditions.

Precipitation was highest for the end of May and June at all sites, but precipitation was limited during the growing season for wheat. Precipitation was significantly greater for the alternative crops in Prowers and Baca counties, however, it was minimal for Weld Co. Both wheat and alternative crops in Weld Co. crops appeared drought stressed.

We continue to extend communications with all cooperators, and growers continue to take interest in the project. We send cooperators a copy of their soil surveys, and, along with these surveys, we send a note to give them a short update of when we will sample and the insects and pests we have encountered during our sampling. In addition, we plan to meet with cooperators during the winter season and give each a report of the 2003-2004 season results.

b. Texas demonstration sites

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Summary

Aphids, Aphids' natural enemies, and weeds data were collected and evaluated for four demonstration sites in the Texas Panhandle during the 2003-2004 growing season. Sampled crops were cotton (one field in Deaf Smith County) sorghum (one field in Hutchinson County), and wheat (three fields: Deaf Smith, Ochiltree, and Swisher Counties). Wheat was not sampled at Swisher County demonstration site from late fall to late spring because of heavy grazing and drought. However, there was sufficient rainfall during the late spring and wheat sprouted and was sampled there after. Wheat at the Ochiltree County demonstration site was wiped out by a hail storm in mid-May and was not sampled there after. Soil and weather data have been collected for all demonstration sites. Densities of aphids, aphids' natural enemies and weeds were summarized as total, maximum, and average for field, Berlese, and sweepnet samples for three wheat fields; and field samples for cotton and sorghum fields throughout this report.

Along with species data collection at areawide IPM demonstration sites in the Texas Panhandle, applicability of remote sensing techniques was evaluated for bird cherry-oat aphid, Russian wheat aphid, and greenbug densities and damage estimations. Aphid and remote sensing data were collected at demonstration sites in Texas, Oklahoma, and Colorado. The major findings of this work are given throughout this report. Three papers from this study were presented at the scientific meetings and at least two papers will be presented in the near future. In addition, at least three publications will be submitted to scientific journals. One manuscript is in preparation and two manuscripts will be written by the summer of 2005.

Deaf Smith County Wheat Demonstration Site: Wheat-fallow-wheat or wheat-fallow-alternative summer crop rotation.

Densities of bird cherry-oat aphid and greenbug started to build up in early fall of 2003, reached the highest amount in January and February of 2004 (Table 1 and 3), and declined during the rest of the growing season. Although there were high amount of bird cherry-oat aphid and greenbug, damage symptoms in wheat were not noticed. Other aphids, in particular rice root aphid, were found from fall 2003 to early spring 2004 but density of rice root aphid never reached a noticeable amount in this field. From early spring to harvesting, Russian wheat aphid infested this field (Table 1 and 3) and patches or hot spots of infestation were noticed by naked eye. In other words, Russian wheat aphid density exceeded the economic threshold value and reduced wheat yield in those patches when compared to un-infested wheat. Remote sensing and Russian wheat aphid data were collected in those infested wheat patches as well as un-infested wheat and briefly discussed in remote sensing section of this report. Natural enemies of aphid (lady beetles, lacewings, spiders, orius, nabids, etc.) were found but densities of these predators did not reach sufficient numbers to keep aphid densities low (Table 1-2). Johnsongrass and crested wheatgrass were common at the field borders and brome spp. were found in the field. Yield data were obtained at this areawide demonstration site.

Table 2: Densities of aphids, beneficial insects, and weeds collected by tiller, row or square meter sampling at the Deaf Smith County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Growth Stages (Zadoks Scale)	Bird Cherry-oat Aphids			Greenbugs			Russian Wheat Aphids			Other Aphids			Gold Mummies			Convergent Lady Beetles			7-Spotted Lady Beetles			Green Lacewings			Brome spp.		
		T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
10.27.2003	15	5	3	0.05	23	17	0.23	.	.	.	3	1	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.02.2003	26	68	11	0.68	216	25	2.16	.	.	.	24	2	0.24	.	.	.	2	2	0.02	.	.	.	.	.	.	.	.	.
01.13.2004	26	143	15	1.43	1231	105	12.31	.	.	.	18	7	0.18	3	1	0.03	.	.	.	.	.	.	.	.	.	.	.	.
02.06.2004	31	99	11	0.99	1097	75	10.97	.	.	.	2	2	0.02	25	4	0.25	.	.	.	.	.	.	.	.	.	.	.	.
03.30.2004	31	78	12	0.78	516	32	5.16	.	.	.	1	1	0.01	42	7	0.42	.	.	.	.	.	.	.	.	.	.	.	.
03.30.2004	40	.	.	.	2	1	0.02	96	72	0.96	1	1	0.01	9	1	0.09	.	.	.	.	.	.	10	5	0.10	25	10	0.25
04.19.2004	40	10	10	0.10	.	.	.	651	120	6.51	.	.	.	.	.	.	3	1	0.03	.	.	.	.	.	.	22	10	0.22
05.07.2004	69	.	.	.	.	.	.	984	312	9.84	.	.	.	.	.	.	12	6	0.12	5	3	0.05	1	1	0.01	.	.	.
05.17.2004	90	.	.	.	.	.	.	1552	358	15.52	.	.	.	.	.	.	13	9	0.13	4	3	0.04	4	3	0.04	.	.	.
06.02.2004	90	.	.	.	.	.	.	494	92	4.94	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

T: Total number of individual aphids, beneficial insects, and weeds from 100 tillers, 25, 1-row-foot, and 100 square meter samples, respectively at the sampling dates. **M:** Maximum number of individual aphids counted on one of the100 tillers, beneficial insects collected in one of the 25, 2-ft wheat row, and weed in one of the 100, 1 m^2 areas at the sampling dates. **A:** Mean number of individual aphids, beneficial insects, and weed from the 100 tillers, 25, 1-row-foot, and 100 square meter samples, respectively at the sampling dates. **.:** Species were not found at the sampling dates.

Table 2: Density of beneficial insects in sweepnet samples at the Deaf Smith County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Nabids			Spiders			Convergent Lady Beetles			7-Spotted Lady Beetles			Lady Beetle Immatures			Green Lacewings			Brown Lacewings			Orius		
	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
03.30.2004	19	5	0.76	5	1	0.20	5	1	0.20	1	1	0.04	.	.	.	9	3	0.36	.	.	.	1	1	0.04
04.19.2004	3	1	0.12	10	1	0.40	5	1	0.20	.	.	.	24	4	0.96	2	1	0.04	.	.	.	.	.	.
05.07.2004	55	8	2.20	31	4	1.24	23	6	0.92	.	.	.	1	1	0.04	.	.	.	1	1	0.04	14	3	0.56
05.17.2004	176	22	7.04	22	3	0.88	33	12	1.32	2	1	0.08	10	8	0.40	.	.	.	1	1	0.04	5	2	0.20
06.02.2004	7	3	0.28	33	7	1.32	4	2	0.16	.	.	.	.	.	.	1	1	0.04	.	.	.	8	3	0.32

T: Total number of beneficial insects collected by 25, 180 degree sweeps distributed throughout the field at the sampling dates. **M:** Maximum number of beneficial insects at one of the 25, 180 degree sweeps at the sampling dates. **A:** Mean number of beneficial insects for the 25, 180 degree sweeps at the sampling dates. **.:** Beneficial insects were not found at the sampling dates.

Table 3: Density of aphids in Berlese samples at the Deaf Smith County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Number of Tillers			Bird Cherry-oat Aphids			Greenbugs			Russian Wheat Aphids		
	T	M	A	T	M	A	T	M	A	T	M	A
10.27.2003	550	63	22	.	.	.	22	5	0.88	.	.	.
12.02.2003	1699	105	67.96	300	44	12.50	44	19	4	.	.	.
01.13.2004	1856	131	74.24	699	53	28	1194	148	51.91	.	.	.
02.06.2004	2845	176	113.80	377	67	15.08	3262	265	130.48	.	.	.
03.30.2004	2990	170	119.60	400	56	16	1608	187	64.32	.	.	.
03.30.2004	1845	113	73.80	14	14	0..56	32	32	1.28	.	.	.
04.19.2004	2483	426	99.32	27	7	1.08	81	12	3	7	1	0.30
05.07.2004	1427	89	57.08	2	1	0.08	27	5	1.08	84	26	3.40
05.17.2004	1333	94	53.32	11	3	0.44	.	.	.	537	132	21
06.02.2004	1588	89	63.52	28	7	1.12	27	7	1.08	476	76	18.96

T: Total number of individual aphids collected from 25, 1-row-foot wheat samples distributed throughout the field at the sampling dates. **M:** Maximum number of individual aphids at one of the 25, 1-row-foot wheat samples at the sampling dates. **A:** Mean number of individual aphids for the 25, 1-row-foot wheat samples. **.:** Aphids were not found at the sampling dates.

Deaf Smith County Cotton Demonstration Site: Wheat-fallow-wheat or wheat-fallow-alternative summer crop rotation.

Low numbers of cotton aphid and beneficial insects were found in cotton field (Table 4). These low numbers of insects in cotton might be related to the weather conditions because the Texas Panhandle had an unusually wet summer in 2004. Field bindweed and pigweed patches were found in the field and Johnsongrass, crested wheatgrass, and jointed goatgrass were common at the field borders.

Table 4: Densities of aphids, beneficial insects, and weeds collected by leaves, plants or square meter sampling at the Deaf Smith County cotton demonstration site in 2004, by date.

Sampling Dates	Growth Stages	Cotton Aphids			Cotton Fleahoppers			Grasshoppers			Thrips			Spiders			Convergent Lady Beetles			Cotton Bollworms			Green Lacewings			Field Bindweed			Pigweeds		
		T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
06.22.2004	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	2	0.24	.	.	.	.	.	.	8	8	0.32	45	7	12
07.05.2004	4	.	.	.	.	.	.	.	.	.	.	.	.	5	2	0.72	20	2	0.80	.	.	.	.	.	.	10	10	0.40	50	10	2
08.03.2004	4	26	12	1.04	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	6	0.24	26	10	1
08.23.2004	4	117	19	4.68	3	3	0.12	25	6	1	67	15	2.68	2	1	0.08	13	3	0.52	.	.	.	7	3	0.28	.	.	.	17	6	.68
09.17.2004	5	16	7	0.64	15	12	0.60	105	11	4.12	.	.	.	1	1	0.04	2	1	0.08	30	3	0.12	3	1	0.12	.	.	.	18	6	.72

T: Total number of individual insects and weeds for 25 samples at the sampling dates. **M:** Maximum number of individual insects and weed at one of the 25 sampling points at the sampling dates. **A:** Mean number of individual insects and weed for the 25 sampling points. **.:** Species were not found at the sampling dates.

Hutchinson County Sorghum Demonstration Site: Wheat-fallow-sorghum rotation.

Corn leaf aphids were found during the entire growing season with one exception that no aphid was found at sorghum growth stages 1 and 9 measured by Vanderlip scale (Table 5). Density of corn leaf aphid reached the highest amount at growth stage 3 or the last week of July 2004. High densities of convergent lady beetle appeared at growth stages 2 and 3 when corn leaf aphid density was the highest. Seven-spotted lady beetles and nabids were rarely found. Pink-spotted lady beetle, green and brown lacewings were always found during the entire growing season but in low numbers. The only weed species in the field and field borders was Johnsongrass.

Table 5: Densities of aphids, beneficial insects, and weeds by plant or square meter sampling at the Hutchinson County sorghum demonstration site in 2004, by date.

Sampling Dates	Growth Stages (Vanderlip Scale)	Corn Leaf Aphids			Nabids			Spiders			Convergent Lady Beetles			7-Spotted Lady Beetles			Pink Spotted Lady Beetles			Green Lacewings			Brown Lacewings			Syrphids			Johnsongrass		
		T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
06.23.2004	1	.	.	.	.	.	.	3	1	0.30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
07.06.2004	2	189	51	18.90	.	.	.	3	2	0.30	108	16	10.80	.	.	.	2	1	0.20	2	1	0.20	.	.	.	.	.	.	1	1	0.10
07.16.2004	2	1463	236	146.30	1	1	0.10	5	2	0.50	98	20	9.80	1	1	0.10	2	1	0.20	2	2	0.20	9	3	0.90	.	.	.	.	.	.
07.30.2004	3	2716	828	271.60	.	.	.	.	.	.	46	9	4.60	1	1	0.10	9	4	0.90	7	2	0.70	10	3	1	.	.	.	10	10	1
08.06.2004	4	118	32	11.80	3	2	0.30	7	2	0.70	5	1	0.50	3	3	0.30	15	3	1.50	4	2	0.40	9	5	0.90	.	.	.	.	.	.
08.12.2004	5	230	45	23	.	.	.	1	1	0.10	3	3	0.30	.	.	.	17	4	1.70	8	3	0.80	5	3	0.50	9	4	0.90	.	.	.
08.24.2004	7	270	130	27	.	.	.	1	1	0.10	7	2	0.70	.	.	.	9	3	0.90	38	11	3.80	15	6	1.50	9	2	0.90	.	.	.
09.08.2004	7	281	91	28.10	1	1	0.10	3	2	0.30	4	2	0.40	.	.	.	4	1	0.40	25	7	2.50	.	.	.	5	2	0.50	2	2	0.20
10.01.2004	8	42	24	4.20	.	.	.	.	.	.	.	.	.	.	.	.	1	1	0.10	.	.	.	1	1	0.10	.	.	.	10	10	1
10.18.2004	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	0.40	.	.	.	.	.	.	.	.	.

T: Total number of individual insects and weeds for 10 samples at the sampling dates. **M:** Maximum number of individual insects and weed at one of the 10 sampling points at the sampling dates. **A:** Mean number of individual insects and weed for the 10 sampling points. **.:** Species were not found at the sampling dates.

Ochiltree County Wheat Demonstration Site: Wheat-fallow-wheat rotation.

Sampling dates, growth stages, population dynamics of species found in this field are presented in Tables 6-8. Greenbug and bird cherry-oat aphid were found at all growth stages. Rice root aphid was another common species with low density in this field. Beneficial insects were found in low numbers in this field. Brome spp. were found in the field and field border as well. Other weed species found at the field borders were crested wheatgrass, jointed goatgrass, and Johnsongrass.

Table 6: Densities of aphids, beneficial insects, and weeds collected by tiller, row or square meter sampling at the Ochiltree County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Growth Stages (Zadoks Scale)	Bird Cherry-oat Aphids			Greenbugs			Russian Wheat Aphids			Other Aphids			Gold Mummies			Spiders			Convergent Lady Beetles			7-Spotted Lady Beetles			Brome spp.		
		T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
11.24.2003	24	217	32	2.17	52	15	0.52	.	.	.	65	21	0.65	.	.	.	.	.	.	1	1	0.01	.	.	.	.	.	.
01.12.2004	26	672	25	6.72	993	58	9.93	.	.	.	98	10	0.98	4	1	0.04	.	.	.	.	.	.	1	1	0.01	.	.	.
01.30.2004	28	391	23	3.91	749	46	7.49	.	.	.	29	10	0.29	8	2	0.08	.	.	.	.	.	.	.	.	.	.	.	.
02.20.2004	30	146	14	1.46	828	54	8.28	.	.	.	1	1	0.01	.	.	.	.	.	.	9	3	0.09	1	1	0.01	.	.	.
03.12.2004	30	295	30	2.95	458	32	4.58	.	.	.	14	3	0.14	167	13	1.67	3	1	0.03	36	3	0.36	13	2	0.13	1	1	0.01
03.26.2004	31	264	30	2.64	373	32	3.73	29	15	0.29	3	1	0.03	157	13	1.57	2	1	0.02	26	3	0.26	10	2	0.10	.	.	.
04.16.2004	45	.	.	.	1	1	0.01	.	.	.	.	.	.	82	5	0.82	13	2	0.13	3	1	0.03	.	.	.	14	7	0.14
05.05.2004	N/A	.	.	.	16	16	0.16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	0.01

T: Total number of individual aphids, beneficial insects, and weeds from 100 tillers, 25, 1-row-foot, and 100 square meter samples, respectively at the sampling dates. **M:** Maximum number of individual aphids counted on one of the100 tillers, beneficial insects collected in one of the 25, 2-ft wheat row, and weed in one of the 100, 1 m^2 areas at the sampling dates. **A:** Mean number of individual aphids, beneficial insects, and weed from the 100 tillers, 25, 1-row-foot, and 100 square meter samples, respectively at the sampling dates. **.:** Species were not found at the sampling dates. **N/A:** Not applicable because wheat was destroyed by a hail storm.

Table 7: Density of beneficial insects in sweepnet samples at the Ochiltree County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Nabids			Spiders			Lady Beetle Immatures			Green Lacewings			Lacewing Larvae			Orius		
	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
04.16.2004	6	2	0.24	8	1	0.32	144	12	5.76	1	1	0.04	.	.	.	4	1	0.16
05.05.2004	20	5	0.48	22	4	0.88	.	.	.	1	1	0.04	4	1	0.16	8	3	0.32

T: Total number of beneficial insects collected by 25, 180 degree sweeps distributed throughout the field at the sampling dates. **M:** Maximum number of beneficial insects at one of the 25, 180 degree sweeps at the sampling dates. **A:** Mean number of beneficial insects for the 25, 180 degree sweeps at the sampling dates. **.:** Beneficial insects were not found at the sampling dates.

Table 8: Density of aphids in Berlese samples at the Ochiltree County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Number of Tillers			Bird cherry-oat Aphids			Greenbugs			Russian Wheat Aphids		
	T	M	A	T	M	A	T	M	A	T	M	A
11.24.2003	1222	87	48.88	92	14	3.68	10	2	0.40	.	.	.
01.12.2004	2034	146	81.36	1081	107	43.24	744	81	29.76	.	.	.
01.30.2004	2384	154	95.36	763	105	30.52	2807	245	112.28	.	.	.
02.20.2004	2889	184	115.56	291	35	11.64	1681	163	67.24	.	.	.
03.12.2004	1961	122	78.44	610	83	24.40	1045	212	41.80	.	.	.
03.26.2004	2324	175	92.96	399	49	16	654	61	26.16	41	7	1.60
04.16.2004	2180	116	87.20	62	43	2.48	9	3	0.36	45	12	1.80
05.05.2004	2180	116	87.20	62	43	2.48	9	3	0.36	.	.	.

T: Total number of individual aphids collected from 25, 1-row-foot wheat samples distributed throughout the field at the sampling dates. **M:** Maximum number of individual aphids at one of the 25, 1-row-foot wheat samples at the sampling dates.
A: Mean number of individual aphids for the 25, 1-row-foot wheat samples.
.: Aphids were not found at the sampling dates.

Swisher County Wheat Demonstration Site: Continuous wheat and grazing.

Greenbug and bird cherry-oat aphid were found in low numbers in fall 2003 but were not in the field in late spring and early summer of 2004 when high densities of Russian wheat aphid occurred (Tables 9-11). Densities of beneficial insects found in this field were low. Common weed species found in this field were field bindweed and lamb's-quarter. At the field borders, Johnsongrass, crested wheatgrass, and jointed goatgrass were found.

Table 9: Densities of aphids, beneficial insects, and weeds collected by tiller, row or square meter sampling at the Ochiltree County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Growth Stages (Zadoks Scale)	Bird Cherry-oat Aphids			Greenbugs			Russian Wheat Aphids			Nabids			Spiders			Convergent Lady Beetles			7-Spotted Lady Bettlesc7			Field Bindweed			Lamb's-quarters		
		T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
10.20.2003	24	3	2	0.03	18	8	0.18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	463	10	4.63	.	.	.
11.09.2003	25	3	1	0.03	2	1	0.02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	283	10	2.83	.	.	.
05.06.2004	31	4	4	0.04	.	.	.	1063	133	10.63	.	.	.	.	.	.	.	.	.	.	.	.	457	10	4.57	40	10	0.40
05.27.2004	69	.	.	.	.	.	.	14252	720	142.52	.	.	.	.	.	.	30	5	0..30	7	2	0.07	363	10	3.63	17	7	0.17
06.07.2004	85	.	.	.	.	.	.	1278	130	12.78	1	1	0.01	3	3	0.03	13	2	0.13	.	.	.	.	.	.	.	.	.
06.21.2004	N/A	.	.	.	.	.	.	.	.	.	.	.	.	11	3	0.11	3	1	0.03	.	.	.	236	10	2.36	72	10	0.72

T: Total number of individual aphids, beneficial insects, and weeds from 100 tillers, 25, 1-row-foot, and 100 square meter samples, respectively at the sampling dates. **M:** Maximum number of individual aphids counted on one of the100 tillers, beneficial insects collected in one of the 25, 2-ft wheat row, and weed in one of the 100, 1 m^2 areas at the sampling dates. **A:** Mean number of individual aphids, beneficial insects, and weed from the 100 tillers, 25, 1-row-foot, and 100 square meter samples, respectively at the sampling dates. **.:** Species were not found at the sampling dates. **N/A:** Not applicable because of grazing.

Table 10: Density of beneficial insects in sweepnet samples at the Swisher County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Nabids			Spiders			Convergent Lady Beetles			7-Spotted Lady Beetles			Lady Beetle Immatures			Orius		
	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A	T	M	A
05.06.2004	24	5	0.96	17	3	0.68	6	2	0.24	1	1	0.04	7	2	0.28	2	2	0.08
05.27.2004	12	3	0.48	8	2	0.32	45	6	1.8	8	2	0.32	33	7	1.32	.	.	.
06.07.2004	29	5	1.16	10	3	0.4	51	8	2.04	3	1	0.12	62	7	2.48	3	1	0.12

T: Total number of beneficial insects collected by 25, 180 degree sweeps distributed throughout the field at the sampling dates. **M:** Maximum number of beneficial insects at one of the 25, 180 degree sweeps at the sampling dates. **A:** Mean number of beneficial insects for the 25, 180 degree sweeps at the sampling dates. **.:** Beneficial insects were not found at the sampling dates.

Table 11: Density of aphids in Berlese samples at the Swisher County wheat demonstration site in 2003-2004, by date.

Sampling Dates	Number of Tillers			Bird Cherry-oat Aphids			Greenbugs			Russian Wheat Aphids		
	T	M	A	T	M	A	T	M	A	T	M	A
10.20.2003	885	71	35.4	.	.	.	68	12	2.72	.	.	.
11.09.2003	1273	90	50.92	23	4	0.92	3	2	0.12	.	.	.
05.06.2004	579	34	23.16	7	3	0.28	.	.	.	191	36	7.64
05.27.2004	774	68	30.96	.	.	.	.	.	.	5205	450	208.20
06.07.2004	420	27	16.8	.	.	.	.	.	.	1012	109	40.48

T: Total number of individual aphids collected from 25, 1-row-foot wheat samples distributed throughout the field at the sampling dates. **M:** Maximum number of individual aphids at one of the 25, 1-row-foot wheat samples at the sampling dates.
A: Mean number of individual aphids for the 25, 1-row-foot wheat samples.
.: Aphids were not found at the sampling dates.

Acknowledgements

Our thanks to Roxanne Bowling, Vanessa Carney, Lana Castleberry, Johnny Bible, Bob Villarreal, Joy Newton, and Daniel Jimenez for their technical support and data collection.

c. *Nebraska/Wyoming demonstration sites*

Written by Gary Hein, John Thomas, Drew Lyon, and Rob Higgins, University of Nebraska

The 2003-04 growing season was a continuation of a multiyear drought in western Nebraska and eastern Wyoming. This drought affected the planned rotations of many of the diversified rotation farmers due to insufficient water to establish or mature the crop.

Plans were established for the diversified growers to plant a portion of their acres to Halt winter wheat (RWA resistant). Halt wheat seed was purchased from a certified seed dealer in Colorado. Upon delivery the seed was determined to be contaminated with jointed goat grass, and we had no time to replace the seed because the cooperating growers were waiting to plant. For this reason there was no RWA resistant seed planted in these rotations for this season.

Nebraska Sites (Banner County)

The paired locations of sites in Nebraska were located in north 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 2003 and continued until the end of the season in 2004. Overall the aphid populations were low until late in the season.

Diversified rotation: The diversified grower 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 use of a spring crop is still variable in his rotation. In fall 2003, winter wheat was planted into the stubble of recently harvested proso millet. Drought conditions were present in the summer of 2003 and as a result poor emergence and a thin stand of wheat occurred. Wheat plants remained relatively small in the fall because drought conditions delayed germination and emergence of the crop. Kangaroo rats continued to be a problem but not as bad as the previous growing season. No aphid infestations were detected in the fall and weed presence was minor.

The wheat continued growth in the spring but the plants did not tiller well to create a good stand. A few RWA were detected in April increasing to a 23% infestation in mid May. This was still considered sub economic because of the poor yield potential this season. By mid June there was an 87% infestation with aphid counts averaging more than 5000 per row foot of wheat (Fig. 1). The poor stand of wheat resulting from drought in addition to RWA and rodents, resulted in an eight bushel per acre yield (harvested July 13). The winter wheat cultivars in the field were Goodstreak and Buckskin neither having RWA resistance.

Greenbugs were also noted in the field in May and June but at very low numbers (<10 per ft). Coccinellids increased following the aphid populations in May and June to a peak in mid June of eight adults and larvae per 25 sweeps (Fig. 2). Nine Aphelinus parasitoids were identified in the June 16, 100 tiller emergence canister sample. No parasitoids were observed earlier.

Few grassy 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. A poor stand of sunflowers resulted from drought, herbicide damage and rodents. Pheromone sampling for the sunflower head moth did not indicate a significant population and the field was not treated with insecticide. 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 Alliance variety winter wheat on September 4. A good stand was obtained in the fall and the crop went into the winter in good shape with very low RWA aphid infestations averaging .08 aphids per foot on November 19. Spring sampling in April indicated a slight RWA infestation of 1% infested tillers in April climbing to 26% infested tillers in mid June with an average of 161 RWA per row foot (Fig. 1). The field was harvested in early July and yielded an average of 26 bushels per acre. This is the lowest yield they have had on these strips in many years. Drought and a light hail shelling out some grain are factors that appear to have impacted the yield most significantly.

No other insect pest or disease problems occurred in the field. Greenbugs were present in the spring with very low populations peaking at 7 per foot on May 20. Coccinellid populations did appear but remained low peaking at only a little over 2 adults and larvae per 25 sweeps on June 24 just before full wheat maturity (Fig. 2). 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 (Laramie Co. Wyo. and Banner Co. Ne.)

The two sites for this pair are located in Laramie Co.Wyoming and just across the border in southwest Banner Co. Nebraska. Growing conditions for this pair of locations was better than most of the surrounding region. These areas saw more rainfall, less drought stress and good establishment of the winter wheat crop.

Diversified rotation: Sampling was initiated in fall 2003 with a new diversified rotational grower in Laramie County Wyoming. The planned rotation in the dryland sampling area is wheat/ sunflower/ corn/ millet/ wheat. Due to drought conditions for the past several years this diversified grower along with many others have had to modify their ideal rotation plan. In 2003 winter wheat was planted into disked corn ground and no till sunflower ground during the first week of September. A good stand of wheat was established in the fall. A very light infestation of RWA existed in the fall with 1% infested tillers and an average of 0.68 RWA per row foot. In April, berlese samples indicated a light RWA infestation of 1.9 RWA per row foot climbing to a 3% infestation in mid May with 5.6 RWA per foot. On June 30 a 35% RWA infestation with 160 RWA per foot developed just before harvest. RWA populations were not high enough in May and June to cause significant economic impact (Fig. 1). Wheat was harvested on July 12 yielding 37 bu/ac which is a little below the historical average of 42 bu/ac. The only significant impact on yield appeared to be moderate drought stress during the spring.

No other insect pests or diseases occurred in the field. Coccinelid larvae and adults became evident in June with sweep catches averaging five coccinelids per 25 sweeps at the end of June (Fig. 2). A few greenbugs were noted in the spring and fall with no samples recorded having more than 2 per row foot. Three *Aphelinus* parasitoids were collected from the June 30 (100 tiller) emergence canister sample. Weeds were not a problem in the fall or spring but a few broad leaf weeds were controlled with a spring herbicide application. Several strips of millet were planted as a summer crop but none of them were harvested due to poor emergence and weed pressure brought on by drought.

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 wheat/fallow grower planted winter wheat the first week of September, 2003 (cv. Ogallala)**.** The wheat crop went into the winter with light to moderate tillering in some areas resulting in areas of light coverage. RWA populations were very low in the fall (<1 RWA per row foot) but a 1% infestation was observed in mid May. This aphid population increased to a 50% infestation averaging 310 RWA per row foot on June 30 (Fig. 1). Maximum coccinellid levels were seen on June 30 at almost 6 adults and larvae per 25 sweeps (Fig. 2). Very low numbers of greenbugs were seen (<2.5 per row foot) in the spring. Six *Aphelinus* parasitoids were collected from the June 30 (100 tiller) emergence canister sample.

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. Heavier rye infestation occurred in the low draw areas. No significant disease impacts were seen in the wheat. The fields were harvested July 12 with some delay because of rains and the wheat yielded 36.24 bu/ac, which is above the average of 30 bu/ac for these fields.

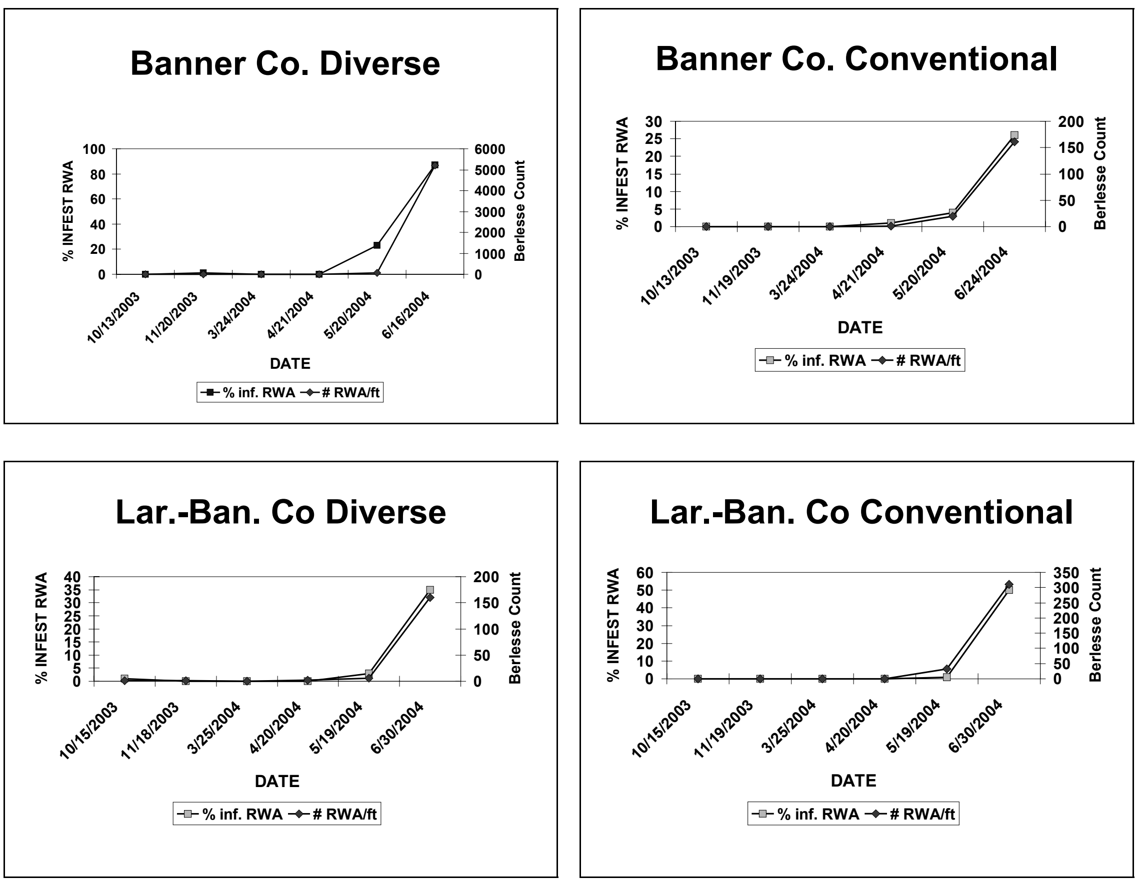


Figure 1. Russian wheat aphid berlese counts and percent infestation from Nebraska and Wyoming sites (2003-04).

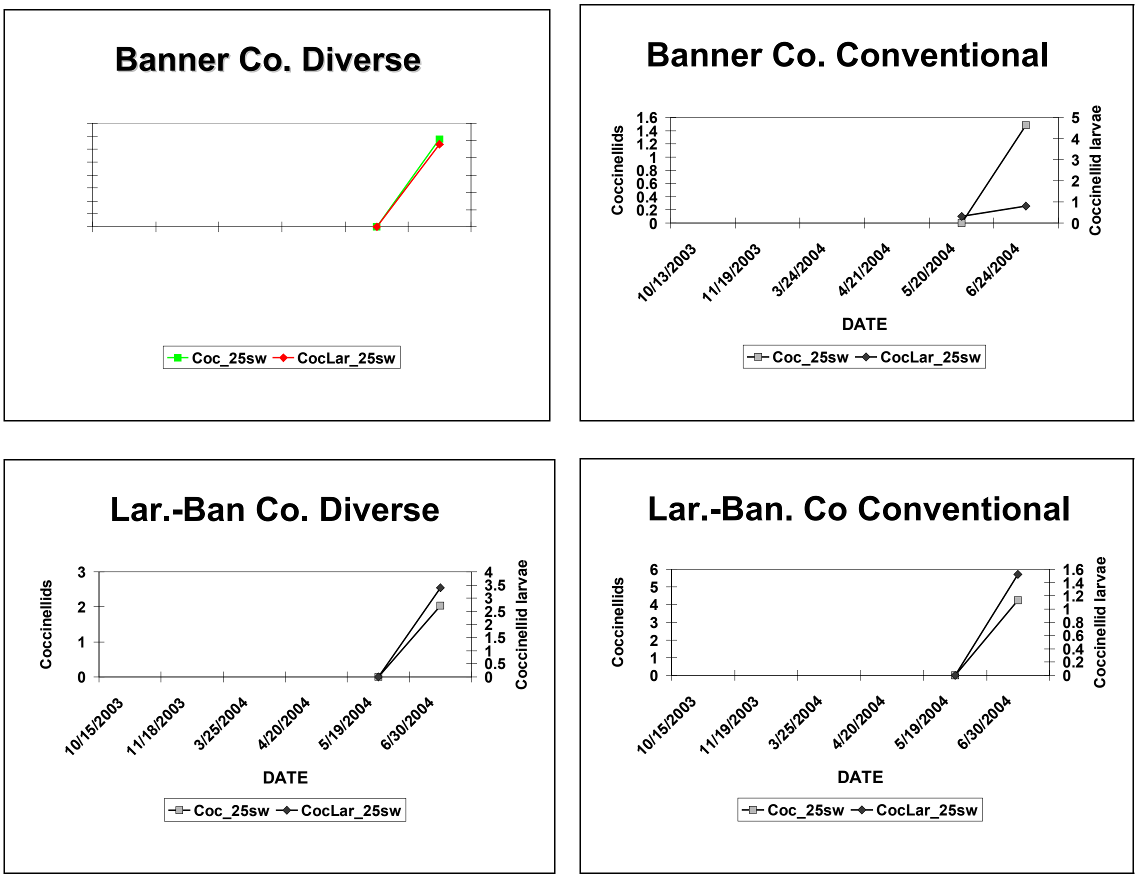


Figure 2. Coccinelid adults and larvae collected in 25 sweep samples at Nebraska and Wyoming sites (2003-04).

d. Oklahoma demonstration sites

Written by Kris Giles and Vasile Catana, Oklahoma State University.
Other Participants: Tom Peeper, Norm Elliott, Dean Kindler, Dave Porter, Kevin Shufran, Mpho Pfoopholo

During the 2003-2004 winter wheat growing season in Oklahoma, 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 sampled in Jackson, Alfalfa, and Kay/Noble counties (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.

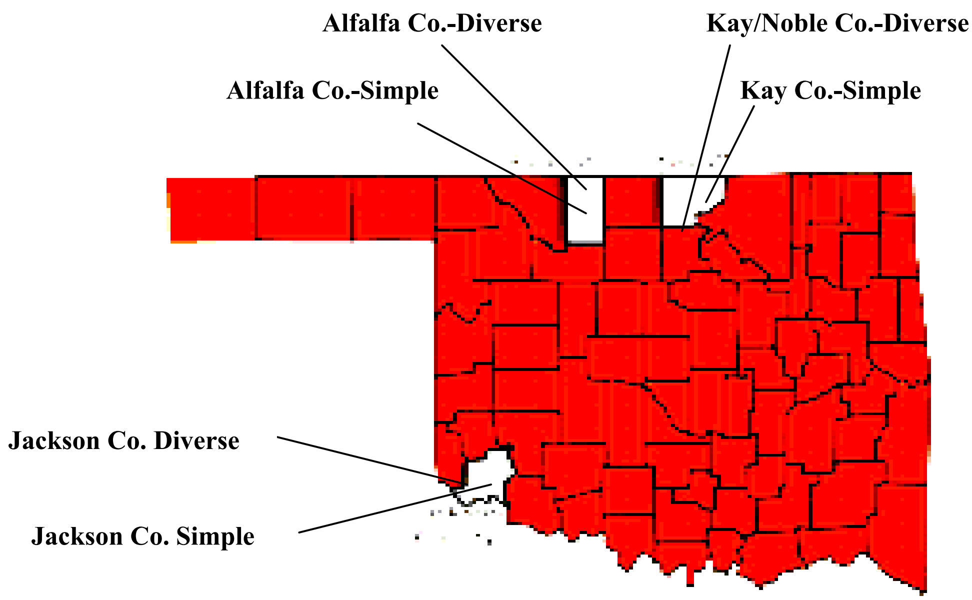


Figure 1. Location of demonstration sites in Oklahoma

Site Descriptions

Jackson County. At the diverse site the grower rotates winter wheat with a variety of different crops including alfalfa, sorghum, corn, peanuts, and cotton (Fig. 2 A). The wheat field was embedded within a diverse landscape which 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).

Alfalfa County. At the diverse site the grower rotates winter wheat primarily with sorghum (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.

Kay/Noble Counties. At the diverse site the grower rotates winter wheat with sorghum. (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.

Grower #3, Jackson Co., Oklahoma

Fig. 2 A. Jackson Co. Diverse

Grower #2, Jackson Co., Oklahoma

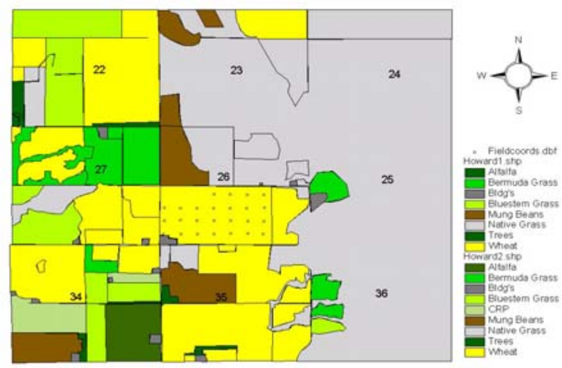


Fig. 2 B. Jackson Co. Simple

Grower #11, Alfalfa Co., Oklahoma

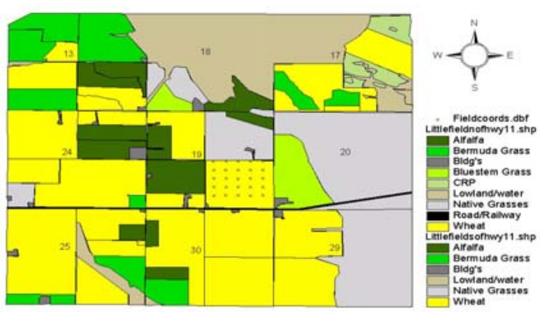


Fig. 2 C. Alfalfa Co. Diverse

Grower #6, Alfalfa Co., Oklahoma

Fig. 2 D. Alfalfa Co. Simple

Grower #7, Kay Co., Oklahoma

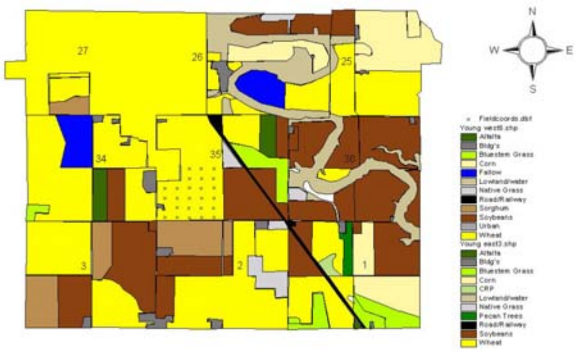


Fig. 2 E. Kay Co. Diverse

Grower #8, Noble Co., Oklahoma

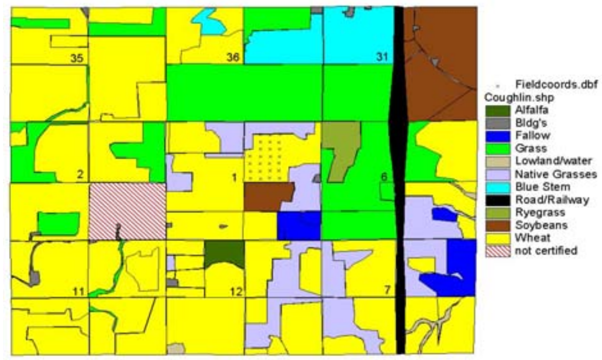


Fig. 2 F. Kay/Noble Co. Simple

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. Compared with the 2002-2003 field season, greenbugs and other aphids were found at higher levels in all of the fields evaluated (Fig. 3; see 2002-2003 report). Compared with the 2002-2003 field season, parasitism of aphids (by several parasitoid species) was less prevalent during the fall and early spring, which may have been the reason for higher levels of aphids (primarily Bird-cherry-oat aphids - BCOA).

For the 2003-2004 field season, aphid abundance on sampled tillers was clearly higher at each simple demonstration site compared with abundance at the corresponding diverse sites (Fig. 3 A-F). The results were most dramatic at the Jackson County sites where aphid numbers peaked at approximately 0.25 per tiller at the diverse demonstration site, but increased to over 4 per tiller in early January at the corresponding simple site (Fig. 3 A and B). The high number of aphids at the diverse demonstration site were nearly all greenbugs, which on short developing wheat can be of concern regarding potential yield loss.

As mentioned previously, parasitism as evidenced by the number of mummies found during sampling was at extremely low levels early on (Fig 3 A-F) and may be a primary reason for the temporary increase in aphids at the simple sites during the fall and early spring. Predator numbers during visual sampling were also at extremely low levels (Fig 3 A-F). The sharp decline in aphid abundance during the early spring was likely due to adverse weather conditions. This decline appears to have benefited wheat at the simple demonstration sites, because natural enemy numbers may have been too low to prevent serious outbreaks of aphids.

Figure 3. A

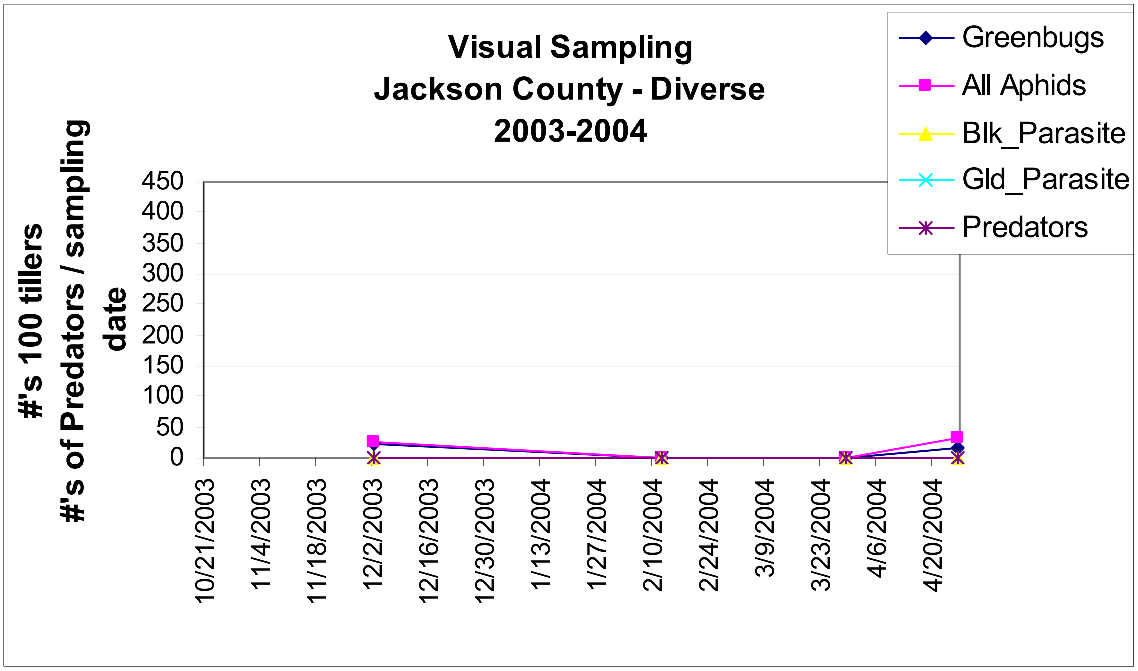


Figure 3. B

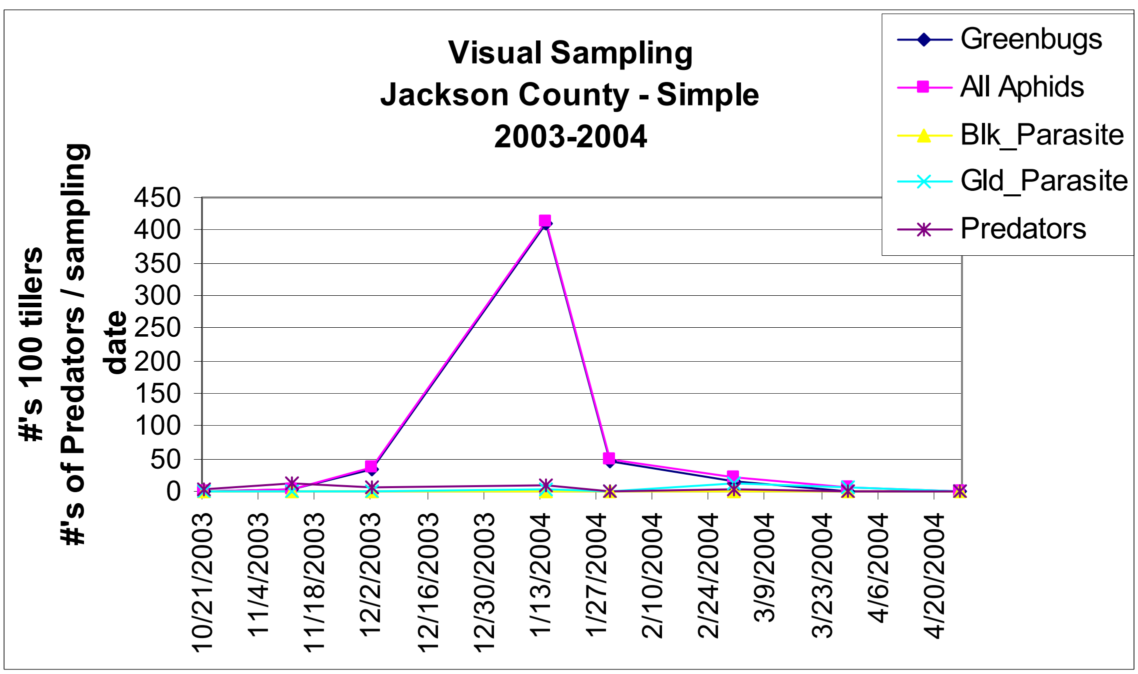


Figure 3 (A and B). Greenbugs, all aphids combined, and mummies (parasitized aphids) in Winter Wheat at Oklahoma Demonstration Sites.

Figure 3. C

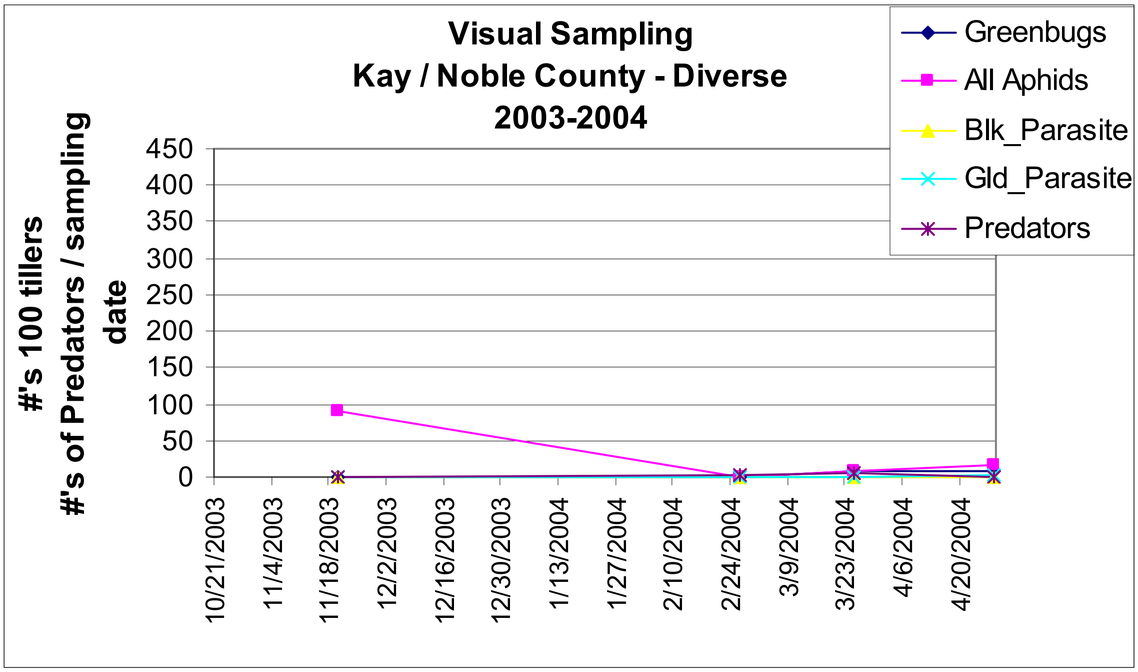


Figure 3. D

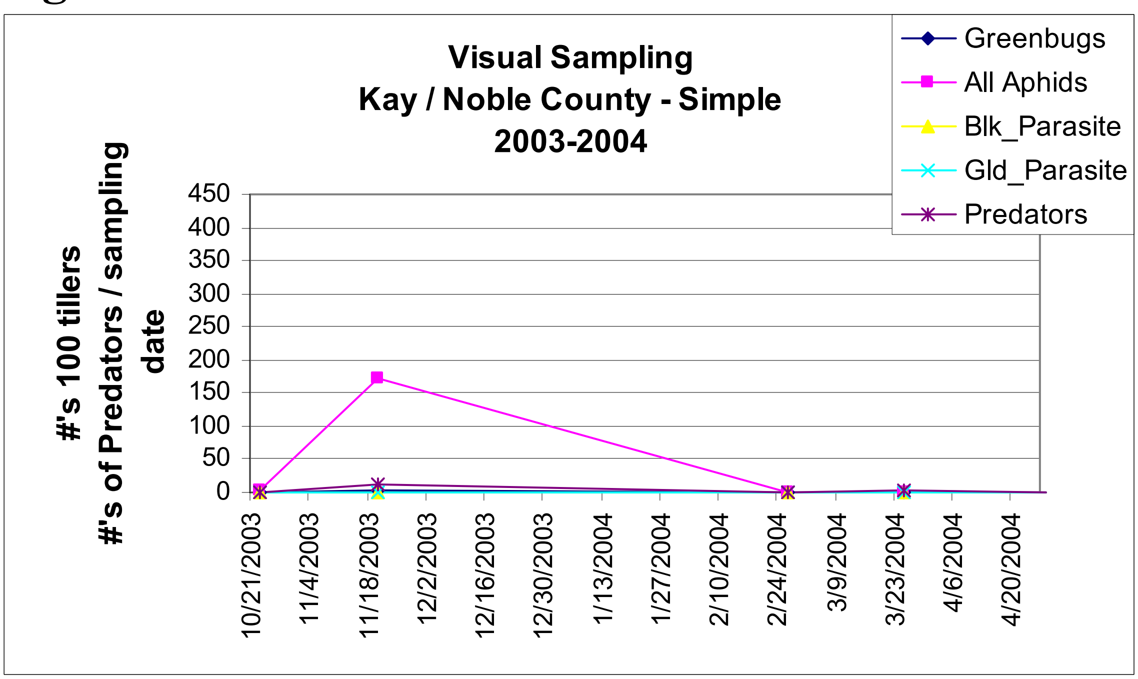


Figure 3 (C and D). Greenbugs, all aphids combined, and mummies (parasitized aphids) in Winter Wheat at Oklahoma Demonstration Sites.

Figure 3. E

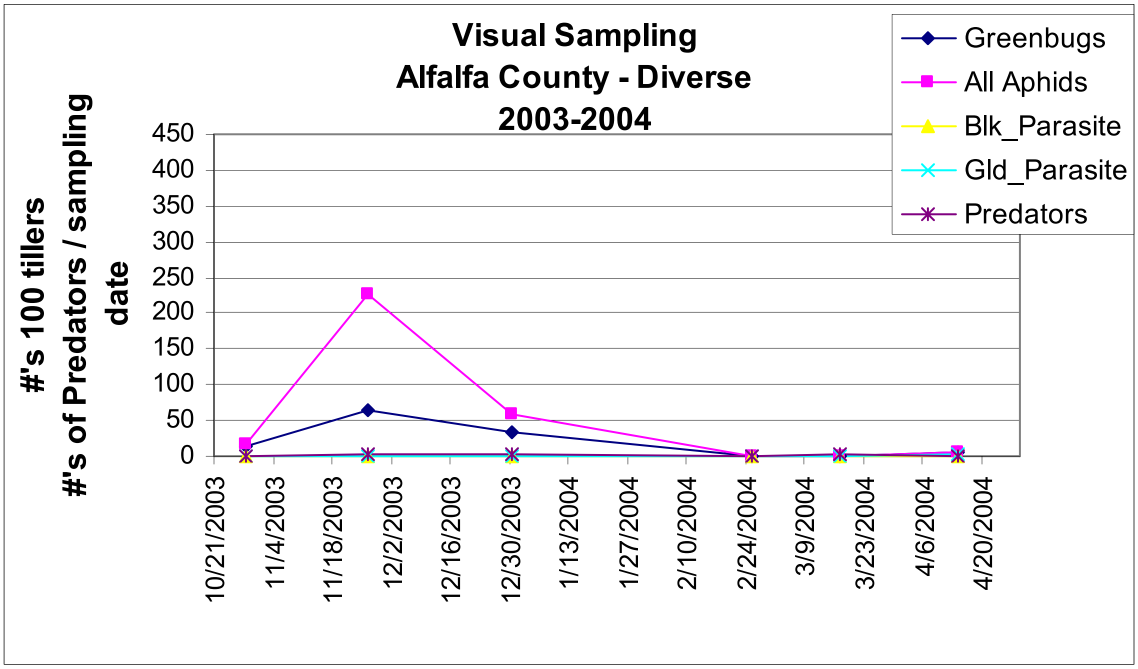


Figure 3. F

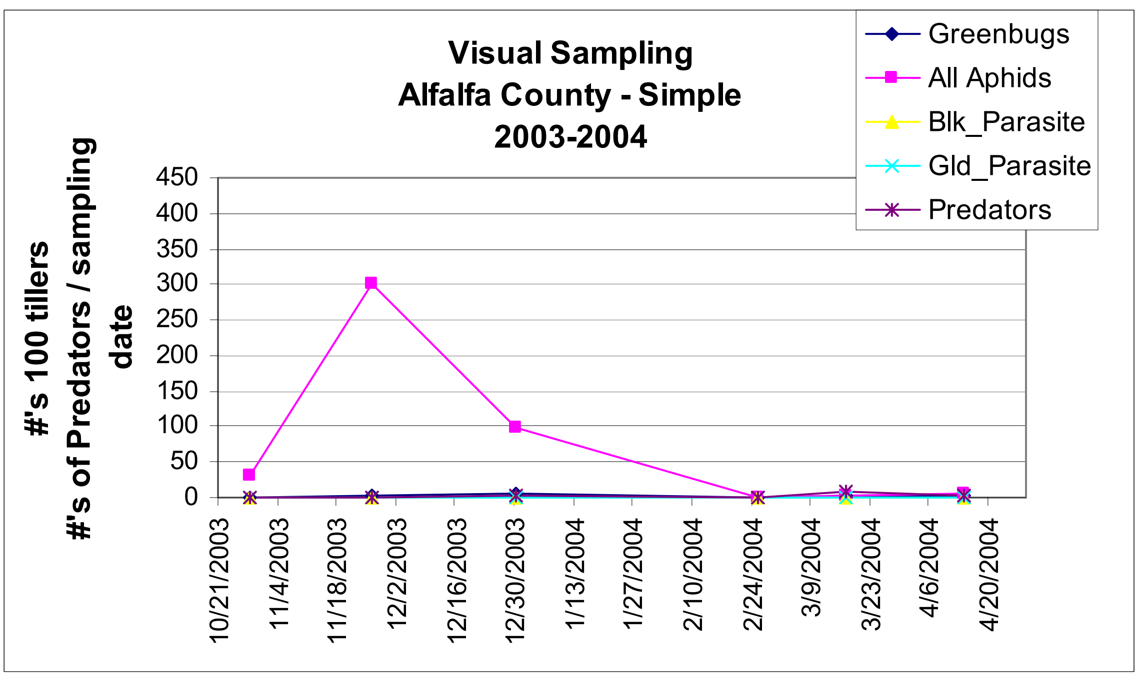


Figure 3 (E and F). Greenbugs, all aphids combined, and mummies (parasitized aphids) in Winter Wheat at Oklahoma Demonstration Sites.

Aphids from burlese samples. . Compared with the 2002-2003 field season, greenbugs and other aphids were found at higher levels in all of the fields evaluated (Fig. 4; see 2002-2003 report). The BCOA and a closely related species the Rice-Root aphid (RRA) represented the majority of aphids found in burlese samples. Greenbugs were generally found at low levels in all of the fields evaluated (Fig. 4 A-E). No noticeable trends in aphid abundance between diverse and simple demonstration sites were observed. Interesting was the higher numbers of BCOA and RRA at during late November at the Alfalfa County diverse site. Note: At the time of this report, Berlese data for the Jackson County diverse site was available for only one date (12/03/03) for the 2003-2004 field season. During this date, the total number of greenbugs and all aphids in burlese samples were 5 and 63, respectively.

Figure 4. A

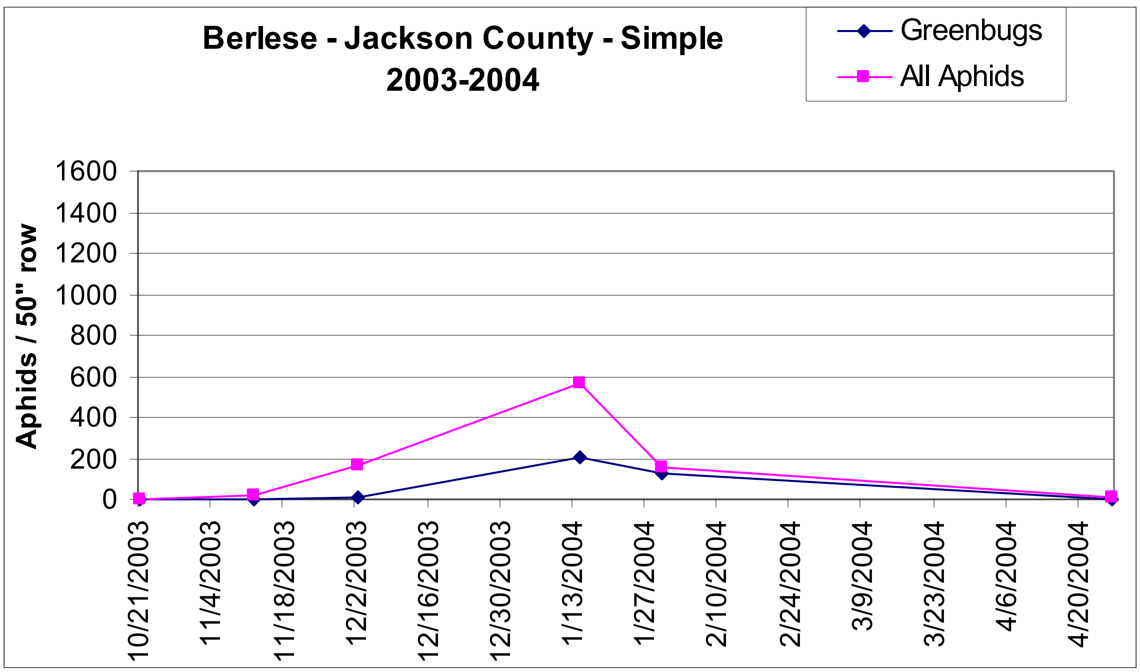


Figure 4 (A). Greenbugs and all aphids in Burlese samples from Winter Wheat at Oklahoma Demonstration Sites. Numbers were summed over twenty five 6"- burlese samples.

Figure 4. B

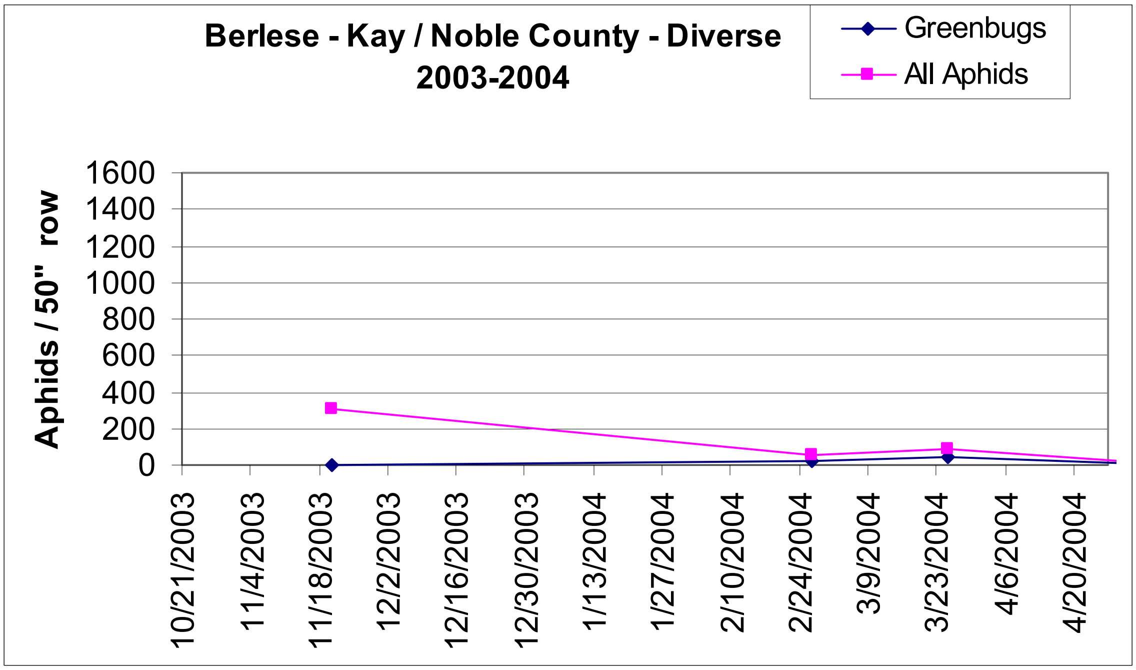


Figure 4. C

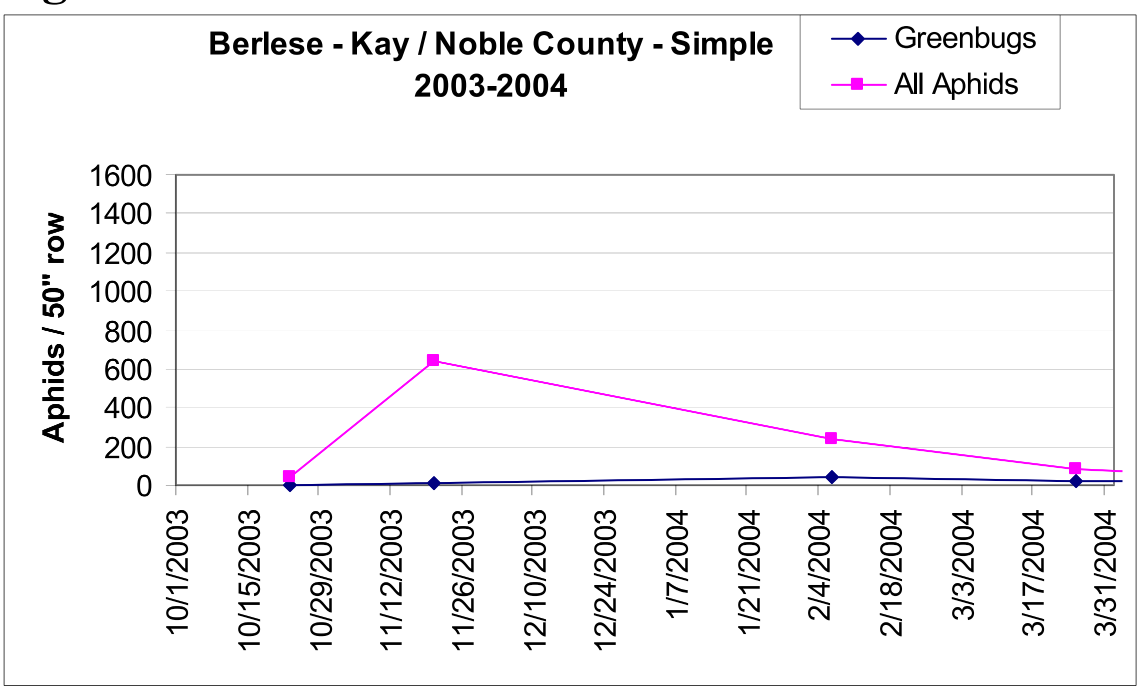


Figure 4 (B and C). Greenbugs and all aphids in Burlese samples from Winter Wheat at Oklahoma Demonstration Sites. Numbers were summed over twenty five 6"- burlese samples.

Figure 4. D

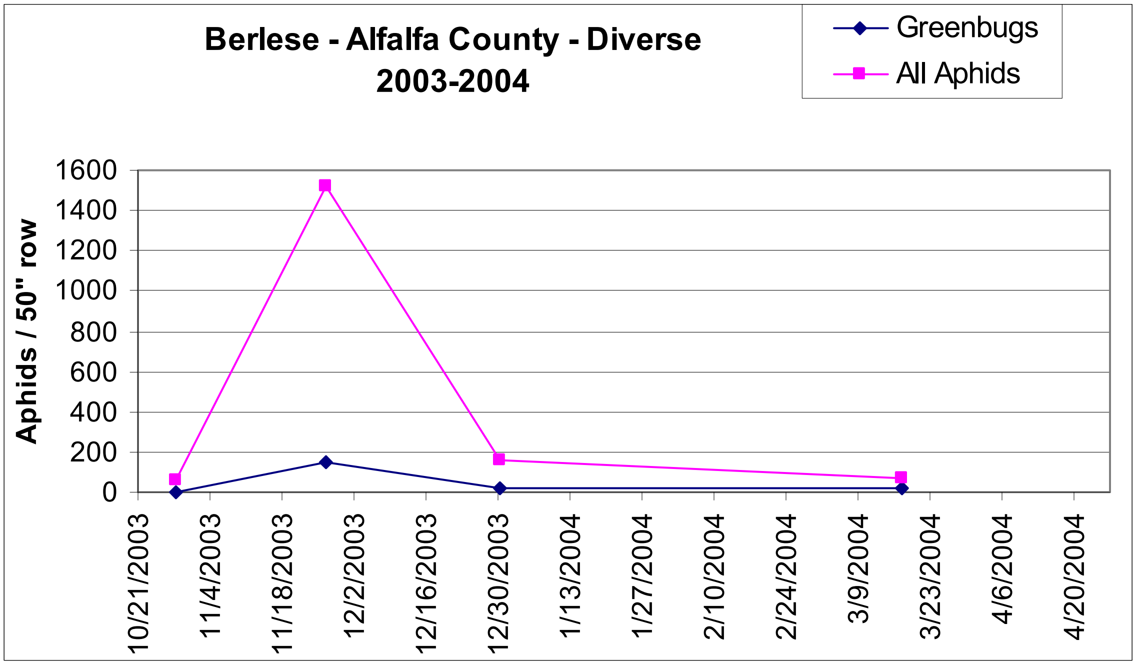


Figure 4. E

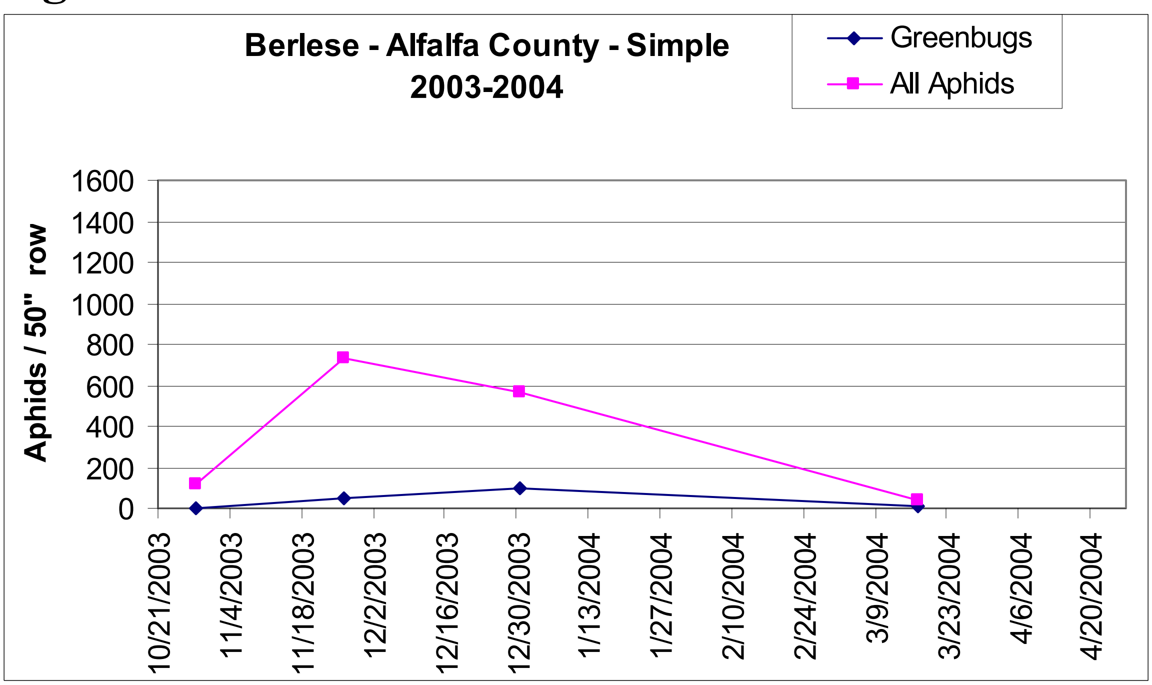


Figure 4 (D and E). Greenbugs and all aphids in Burlese samples from Winter Wheat at Oklahoma Demonstration Sites. Numbers were summed over twenty five 6"- burlese samples.

Predators from sweep samples. Predators in general were found at low levels in all of the fields evaluated (Figs. 3 and 6). Data available for summarization at the time of this report is restricted to Jackson County over two dates during the spring. Higher peak numbers of predators were found at the simple site in Jackson County, compared with numbers at the diverse site. This trend appears at odds with our hypothesis that diverse habitats would support larger numbers of predators. However, a close examination of the total aphids available as prey for these predators (tiller samples; Fig. 3 A-F) indicates that a higher proportion of predators to aphids did occur at the diverse site.

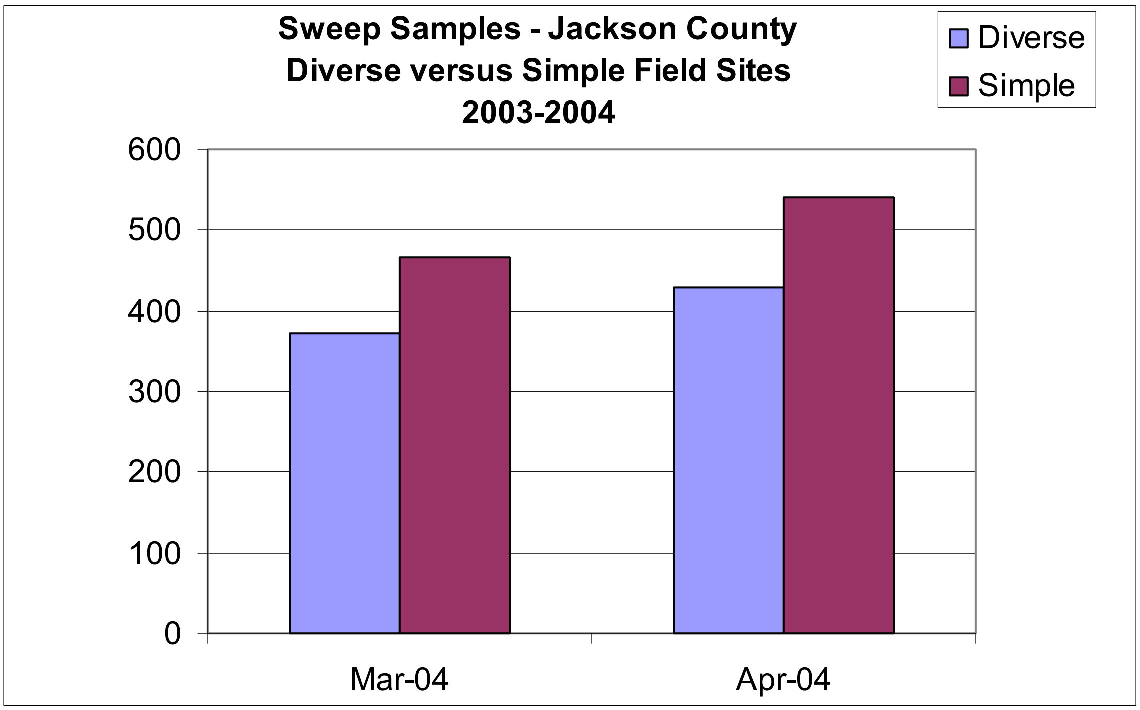


Figure 6. All arthropod predators in Sweep Samples in Winter Wheat at the Jackson County Oklahoma Demonstration Sites. Numbers were summed over twenty five 25-sweep samples.

Other Measures

Weeds. Similar to the previous field season, weeds were found at low-to-moderate levels in all of the fields evaluated, and no significant differences appeared to exist between diverse and simple sites. Interestingly, at both Alfalfa County sites, moderate to high levels of volunteer wheat was observed. Data is continuing to be summarized.

Arthropods in alternative crops. Again, similar to the previous field season, in sorghum, aphids (primarily cornleaf aphids and greenbugs) were present at all sites, but were reduced by parasitism. The continuous levels of parasitism throughout the sorghum growing season suggests that *L. testaceipes* is conserved in diverse systems.

e. Kansas demonstration sites

No progress report was provided for FY 2004. Due to a lack of aphid populations in Kansas and programmatic changes requiring redirection of some AWPM funds into educational and outreach activities, this site will not be monitored as part of the AWPM demonstration project in FY 2005.

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

Written by Vasile Catana, Oklahoma State University.
Other participants: Norm Elliott, Kris Giles, Dean Kindler, Mpho Phoofolo

Introduction Recent advances in Information Technology (IT) impact plant protection. There are two technologies that are particularly applicable to plant protection. The first is Geographic Information System (GIS) software that is frequently used in modern plant protection. Another IT element applicable to plant protection is the database concept. Database and GIS software can form a very powerful symbiosis in plant protection if they are correctly organized and implemented. GIS software has the capability to connect to databases (local or remote) using a variety of methods. If the sampling locations are georeferenced using GPS, survey data can be analyzed and interpreted using the arsenal of powerful GIS analytic tools.

Our Area Wide Pest Management Project (AWPMP) involves teams of entomologists and weed scientists from six states situated on the Great Plains of the USA: Colorado, Kansas, Nebraska, Oklahoma, Texas, and Wyoming. A goal of the AWPMP is to monitor aphid populations regionally and to establish the causes for pest outbreaks.

Data Collection We established 23 typical production winter wheat fields (Fig. 1) throughout our study region. On each field we established 25 regularly distributed sampling points that are georeferenced using GPS. Sampling each field is accomplished using several methods: field sampling that includes a series of counts of aphids and their predators and parasitoids; Berlese sampling to establish the aphid species and their density; emergence canister sampling to establish the intensity of parasitism and parasitoid species; and sampling weeds that can serve as alternative hosts for aphids. For each method we developed a simple template on a Pocket PC using FarmWorks SiteMate© that facilitates entry of field data. The Pocket PC is equipped with a GPS for georeferencing sampling points. The structure of the sampling data collected in the field contains the majority of indexes included in all sampling data. The place and the sampling method are determined by longitude, latitude, elevation, object ID, state, county, grower, crop, date, growth stage, pest unit, predator unit, and weed unit for sampling. The aphid species are Bird Cherry-oat Aphid (BCOA) - *Rhopalosiphum padi* (L.), Greenbug (GB) - *Schizaphis graminum* (Rondani), Russian Wheat Aphid (RWA) - *Diuraphis noxia* (Mordvilko), Other aphids (In this group are the Corn leaf aphid (*R. maidis*), the English grain aphid (*Sitobion avenae*), and rice root aphid (*Rhopalosiphum rufiabdominalis*). Black and gold mummies are counted separately to distinguish the two groups of parasitoids. In the predator group the more important species are distinguished individually, e.g. *Hippodamia convergens*, *Coccinella septempunctata*, *Coleomegilla maculata*, and *H. sinuata.* But some predators that correspond to the same genus (tribe, family, etc.) we combine as a single entry to reduce the volume of collected information. These groups include spiders, nabids, carabids, staphylinids, syrphids, Geocoris, Orius, Scymnus, green lacewings, and brown lacewings. We also sample other important pests such as pest mites, fall armyworm, armyworm, army cutworm, and the important weeds.

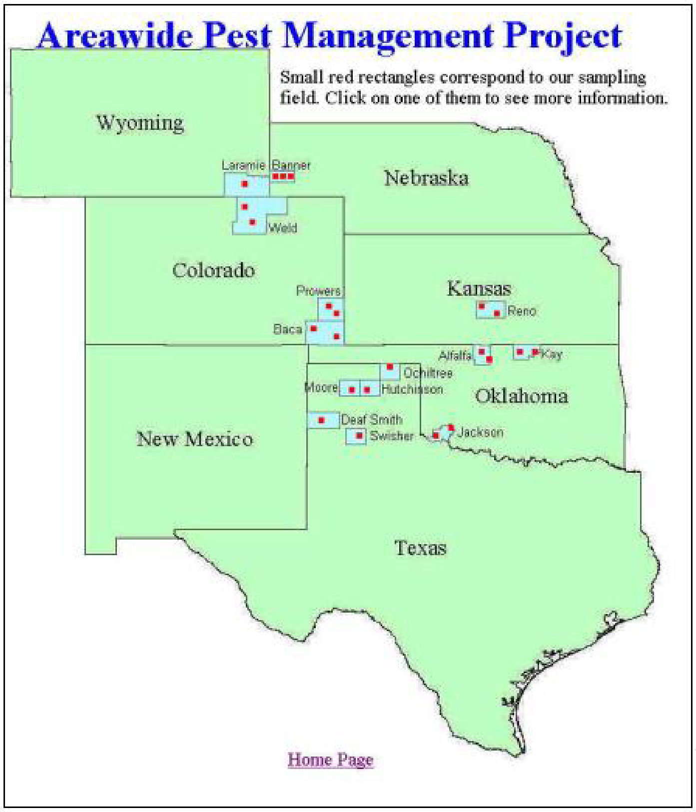


Fig. 1

Database Development and Implementation We organized a computer with Windows 2003 Server © operating system and installed Oracle 9i© on it. We developed a database on the server with a structure that corresponds to the field collected data (Fig. 2). Using Microsoft Visual Studio© we developed a client – server application that allows all project participants involved in AWPMP to visualize, input, and correct their collected data from their computers. On our ftp site at the address ftp://199.133.145.58/ we published the instructions on how to install and use the database software. Once a file with field sampling data is downloaded from the Pocket PC to a Desktop PC we can download the data in Excel format to visualize and make any necessary corrections. The Visual Basic software we developed is able to read Excel tables, to check the structure of these tables, and to localize any errors with corresponding prompts. After that process, the data from the Excel tables is directly incorporated into a common Oracle 9i project database (Fig. 3). Each Excel table has a Constant part and a Variable part of information. The Visual Basic application will separate these two parts and will put them in corresponding database tables that are linked logically by a common key.

The Visual Basic application implements OO4O (Oracle Objects for OLE) that is a part of the Oracle Net Manager Tool ©. OO4O facilitates the pr ogramming work in the Visual Studio environment. Oracle Net Manager is installed on each PC involved in our project and it is responsible for establishing a secure link with our remote database. We chose the Oracle products because they are efficient and stable. In Fig. 4 is a simplified flowchart of the structure of the application.

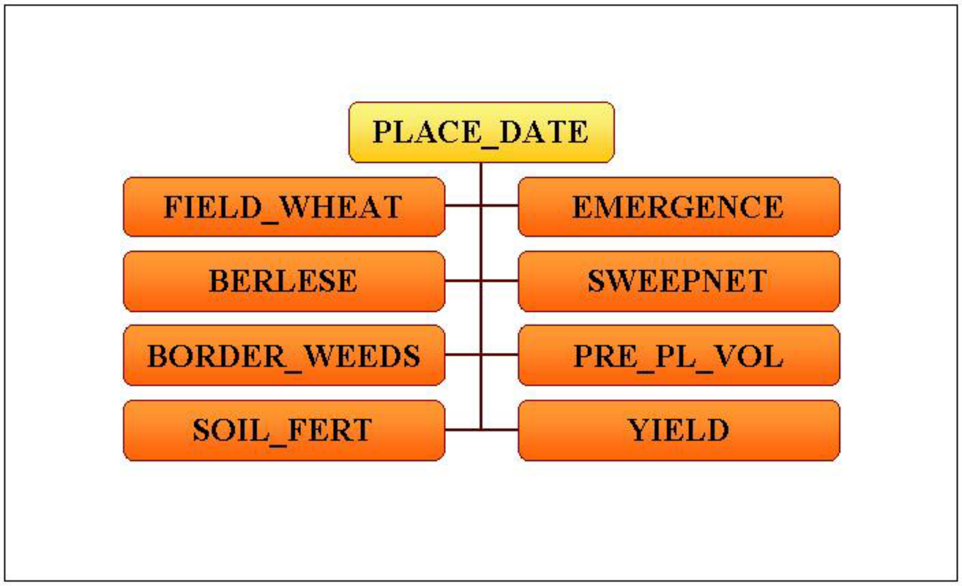


Fig. 2

Input Data Application Interface

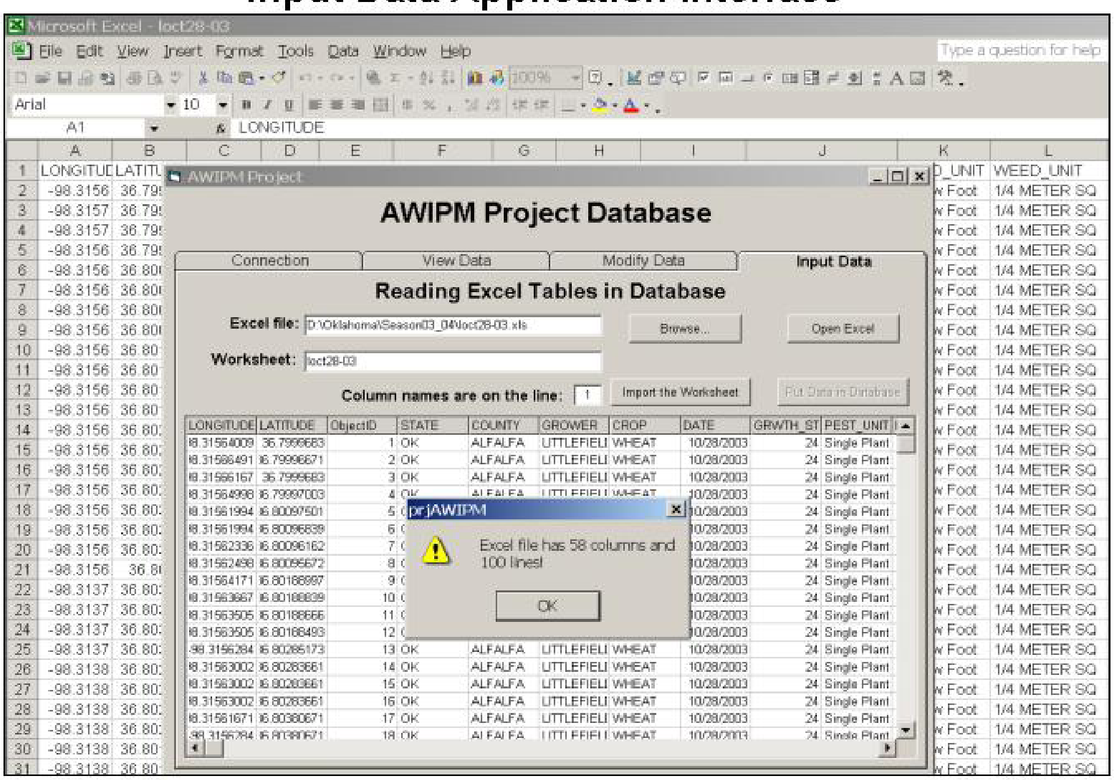


Fig. 3

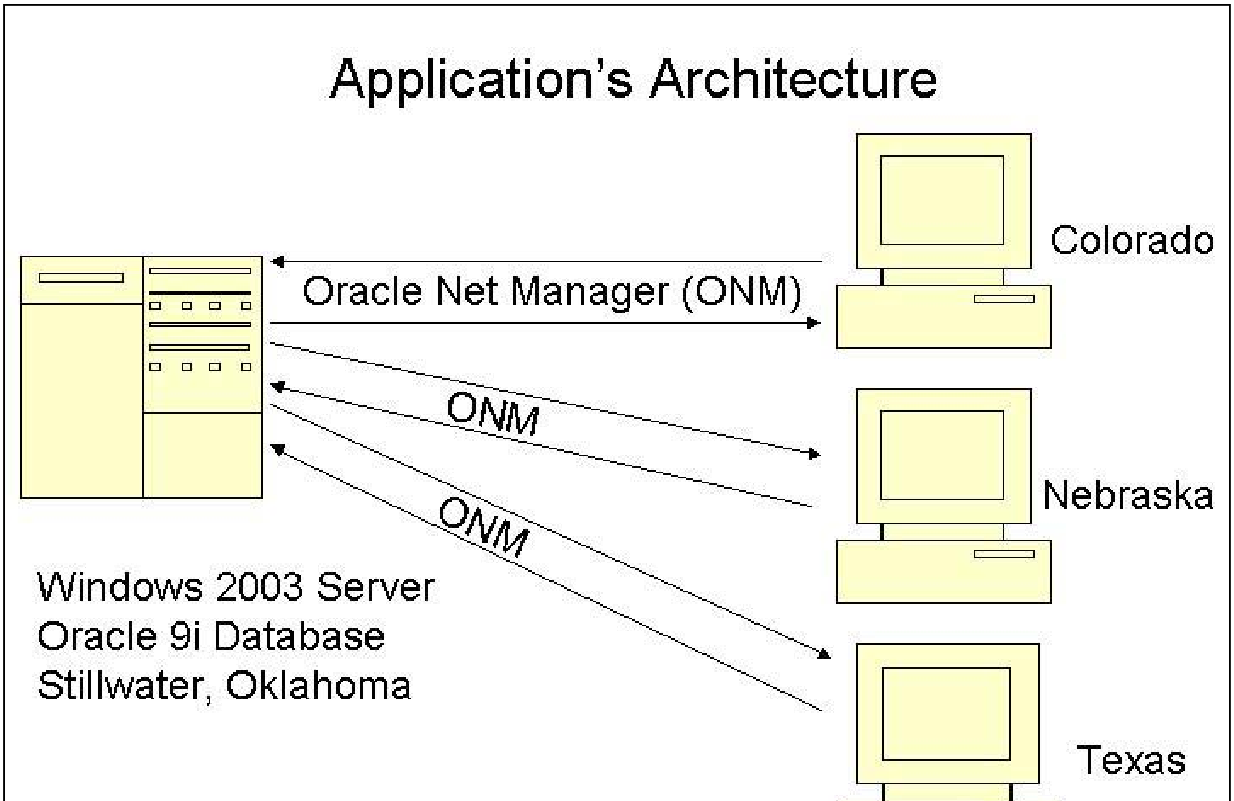


Fig. 4

AWPMP Perspectives. In the future we hope to develop a larger infrastructure based on our Oracle database. First of all we can link the database with GIS software and make analyses of aphid populations at regional scale. We can more precisely conduct our project and establish new conformity to natural laws. We can use the theory of landscape and metapopulation ecology to interpret results. Secondly, we can develop WEB applications that will be linked with the Oracle database to provide near real- time updates to growers of current pest conditions in their region. Fig. 1 represents the beginning of this kind of work. This is the start page of our future Web application. We can develop graphical methods for data interpretation to facilitate the spatial – temporal visualization of pest population dynamics across the region. An exciting and interesting application of the database is development of some forecasting methods to predict the pest population evolution, to detect the preliminary environmental conditions that can cause a pest outbreak, and to determine the role of predators and parasitoids in pest population regulation. This is an important objective of the project because we will have the ability to study the dynamics of insect populations and their interaction using a spatial – temporal approach. Figs 5 - Fig. 8 represent an attempt to describe the evolution of a aphid population in one of our sampling fields in Oklahoma, Jackson county. Figs. 9 - 10 represent the predator population in the same field. The surfaces are constructed using a Kriging procedure from SAS©.

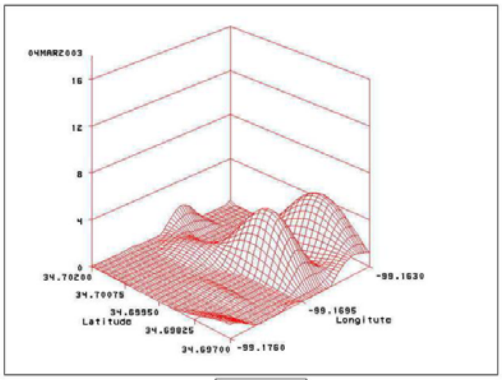


Fig. 5

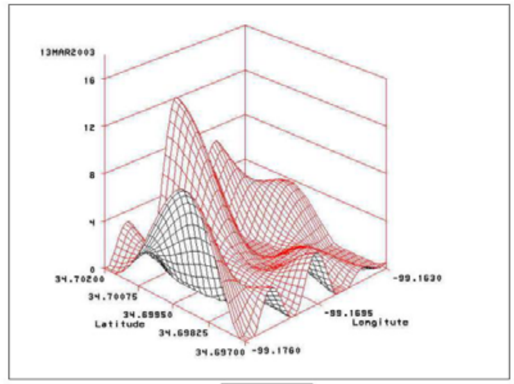


Fig. 6

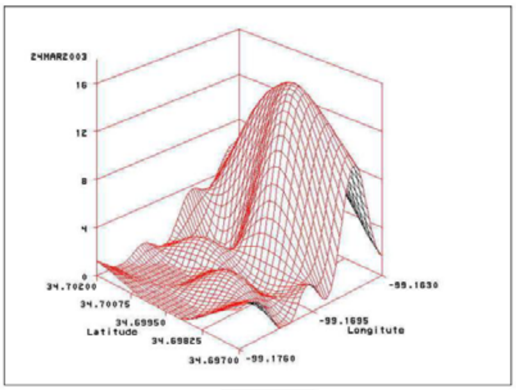


Fig. 7

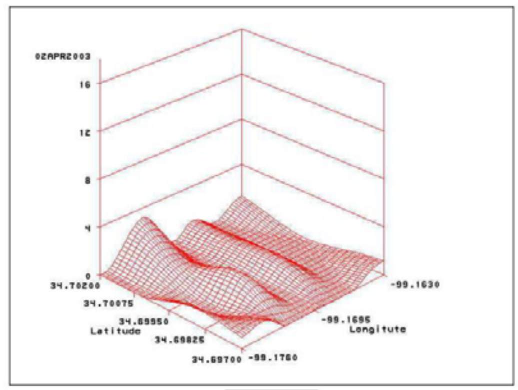


Fig. 8

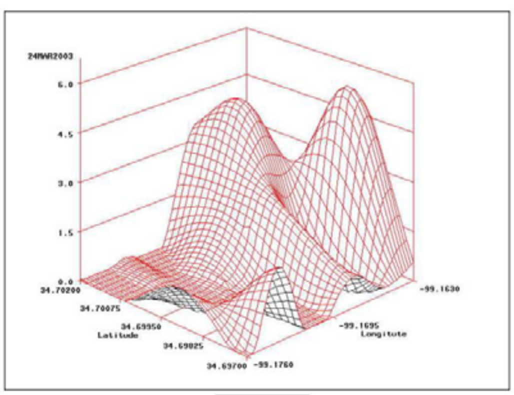


Fig. 9

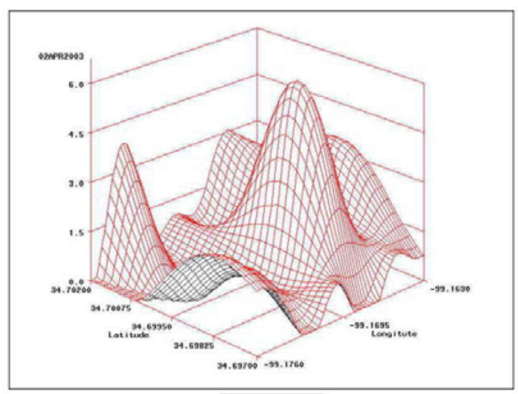


Fig. 10

3. Research Component Summaries

a. Remote Sensing of Greenbug and Russian Wheat Aphid Infestations

i. Characterization Of Aphid-Induced Stress In Wheat Under Field Conditions Using Remote Sensing

Written by Mustafa Mirik
Other Participaants, Gerald J. Michels Jr., Norman C. Elliott, Sabina Kassymzhanova-Mirik, Roxanne Bowling, Vanessa Carney, Lana Castleberry, Johnny Bible, Bob Villarreal, Joy Newton, Denial Jimenez, Vasile Catana, Timothy D. Johnson

During the late fall of 2003 and spring of 2004, the feasibility of a commercially-available hyperspectral hand-held remote sensing instrument to predict aphid density and damage was studied. The following paper summarizes the major findings of the research and it was published in 2004 Bushland Agricultural Day (Summer Crop Field Day) Proceedings (p. 88-98).

Abstract: This work was carried out to investigate the relationship between remotely sensed data and aphid density in field conditions. A hyperspectral ground spectrometer was used to collect percent reflectance data over 0.25 m^2 aphid stressed and non-stressed wheat (*Triticum aestivum* L.) plots in the fields located in Texas, Oklahoma, and Colorado. Bird cherry-oat aphid (*Rhopalosiphum padi* Linnaeus), greenbug (*Schizaphis graminum* Rondani), and Russian wheat aphid (*Diuraphis noxia*) were counted in each of the 0.25 m^2 aphid stressed wheat plots. Paired t-test indicated that percent reflectance values in the 400-900 nm region of the spectrum from aphid stressed and non-stressed wheat were statistically significant. In addition to the statistical comparison of percent reflectance, a total of 25 spectral vegetation indices were calculated from the reflectance data and regressed against the number of aphids. A wide array of relationships was found between spectral reflectance and aphid density. For example, the R^2 values were 0.85 for greenbug plus bird cherry-oat aphid and 0.97 for Russian wheat aphid. These preliminary results strongly indicated that remote sensing techniques, both hyperspectral and multispectral imageries, are highly promising to predict aphid density and discriminate aphid-induced stress form un-infested wheat in field conditions.

INTRODUCTION

Both hyperspectral and multispectral remote sensing technologies have undergone rapid development for a wide setting of applications including precision agriculture because they assist researchers in generating a variety of information at regional and global levels. In addition, various authors (Gemmell and Varjo, 1999; Bork et al., 1999) have argued that remote sensing has advantages over the traditional ground-based monitoring methods, because the latter is laborious, slow, limited to the localized areas, subject to the great variation, and constrained by the lack of access. In addition, the same remotely sensed data can be used for multiple purposes by the same or different investigators.

In recent years, the use of remote sensing has dramatically increased the ability of scientists, managers, and decision-makers to study spatial data in terms of collecting, storing, manipulating, processing, visualizing, integrating, quantifying, monitoring, and managing the available information for present and future needs. Much effort has been assigned to estimate crop characteristics, such as green canopy health and cover, and to discriminate them in a spatially complete manner using visible and infrared spectral data. The goal of the present study was to evaluate the remotely sensed data to detect aphid infestation and estimate aphid density in wheat fields.

METHODOLGY

We collected aphid density; greenbug and Russian wheat aphids; and spectral reflectance data in and over stressed and non-stressed 0.25 m^2 wheat plots in TX, OK, and CO. Reflectance data and digital images were gathered by a hyperspectral ground spectrometer and a digital camera over aphid infested wheat and un-infested wheat nearby. Sometimes, at least 30 tillers were cut at ground level and transported to laboratory to count the number of aphids per 0.25 m^2 sample plot. The remaining tillers in each plot were tallied in the fields to estimate aphid density for each sample plot (Figure 1). The other times, aphid density was determined in the fields by counting all aphids within plots during the early growing season (Figure 1) or clipping all plants and counting aphid in the laboratory during the late growing season (Figure 1). All in all, aphid density was determined at 0.25 m^2 level for each sample. This methodology was applied to all sites for determining actual aphid density in this study.

Figure 1: Clipping wheat in a 0.25 m^2 plot to be transported to laboratory so as to count aphid (left), counting aphid on wheat plants in laboratory (middle) and in the fields (right).

RESULTS AND DISCUSSION

Reflectance patterns gathered by Ocean Optics ground hyperspectral spectrometer for greenbug stressed alone, combination of greenbug and abiotic-stressed and non-stressed wheat near Dumas, Texas were plotted across the visible and near infrared (NIR) range of the spectrum

(400-900 nm) and displayed in Figure 2. As it seen in Figure 2, Non-stressed wheat reflected less light than aphid stressed alone and combination of abiotic and aphid stressed wheat in the visible part of the spectrum but this trend switched in the NIR spectral window. The similar results were observed by plotting the visible and NIR reflectance data collected near Amarillo, Texas for Russian wheat aphid and abiotic stress and non-stress in wheat as well as exposed soil. Figure 2 depicts what was expected that healthy wheat absorbed more visible light for photosynthesis, while injured plants caused by aphid were not able to capture as high light as healthy wheat did for biomass accumulation. This result is in agreement with the findings of Riedell and Blacmer (1999) who reported the spectral properties of Russian wheat aphid and greenbug feeding effects in wheat at the leaf level.

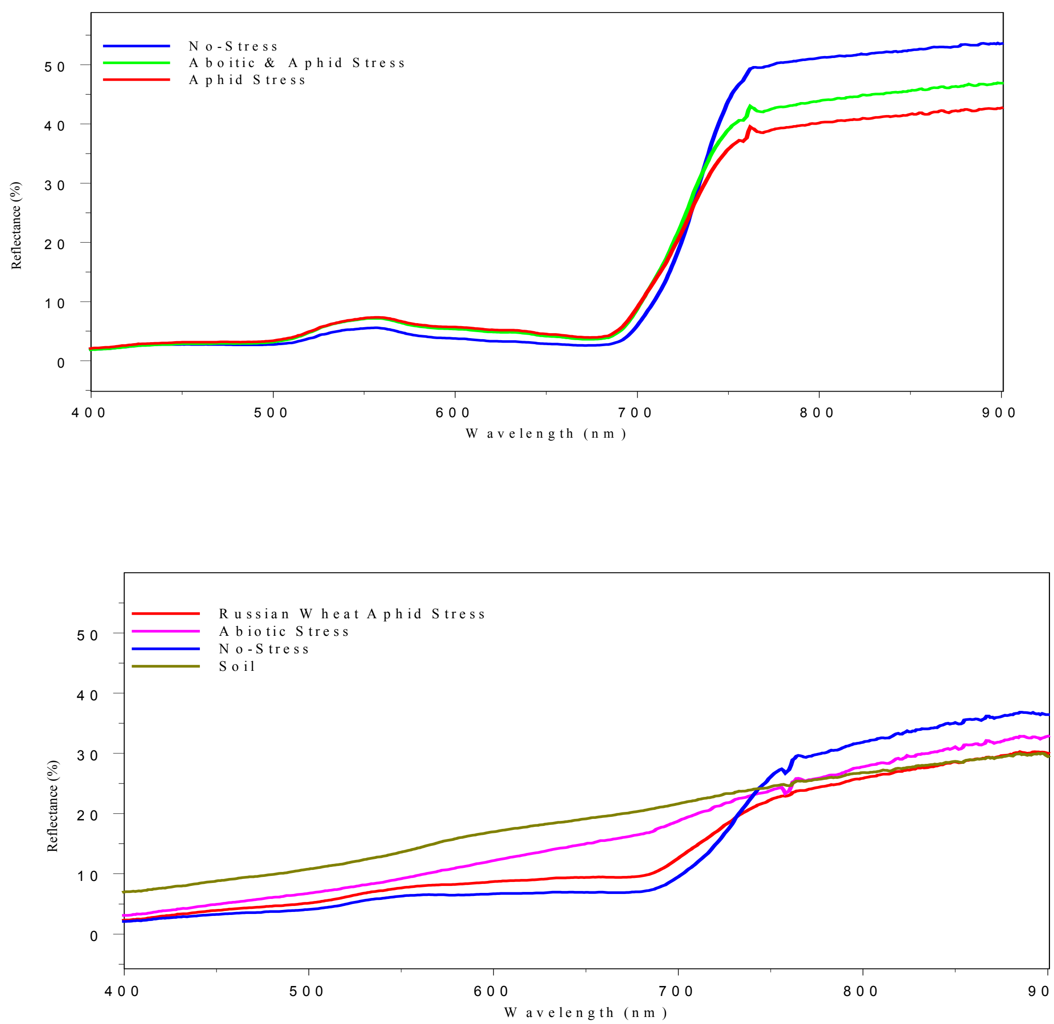
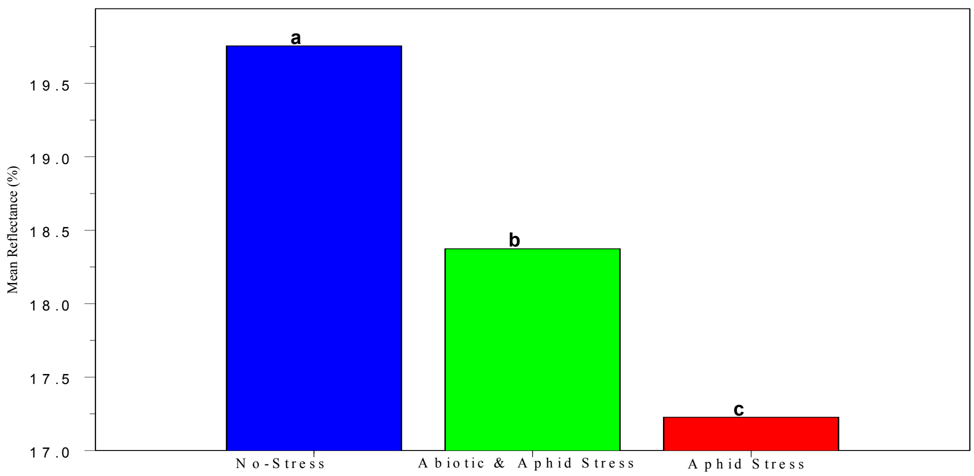


Figure 2: Spectral properties of greenbug-stressed alone, combination of abiotic and greenbug-stressed, and non-stressed wheat (top), Russian wheat aphid-stressed, water-stressed, healthy wheat, and exposed soil (bottom) across the visible and NIR spectrum.

Mean comparison of reflectance data collected for healthy, combination of greenbug and abiotic stress, and aphid stress alone in wheat crop was made and statistically significant difference was found among the entities in question across the visible and NIR spectrum (Figure 3). The same comparison was also made for the Russian wheat aphid stressed and healthy wheat and it resulted with the similar outcomes to greenbug (Figure 3). Both Figures, 2 & 3, strongly suggest that use of hyperspectral or multidate imageries to delineate aphid-induced stress in wheat because most of the image analyses are based on the statistical similarities and/or dissimilarities between or among the surface properties found in an imagery. For our case, surface properties are aphid stressed; or other types of stress; and non-stressed wheat in the fields.



Wavelength (nm)	Russian Wheat Aphid Stress	No Stress
400 - 500	a	b
500 - 600	a	b
600 - 700	a	b
700 - 800	a	b
800 - 900	a	b
400 - 900	a	a

Figure 3: Statistical comparison of three levels of stress measured by reflectance data: greenbug, combination of greenbug and abiotic (top), Russian wheat aphid stressed and non-stressed in wheat (bottom) in the visible and NIR range of the spectrum. Note: Different letters in adjacent columns indicate statistical significance at $\alpha = 0.05$

One of the digital images of greenbug infested wheat plots is shown in Figure 4. Digital images of greenbug-induced stress in wheat were analyzed using ASSESS (Image Analysis Software for Plant Disease Quantification) and percent greenbug damage was estimated as shown in Figure 4. A strong correlation (R^2 = 0.85) was found by regressing the percent damage against greenbug density (Figure 4). The negative slope of the regression line or increased percent greenbug damage while decreasing greenbug density in Figure 4 makes sense because most likely greenbug moved to new spots from injured plants or died due to reduction in food resources. This also appears to be a function of sampling date.

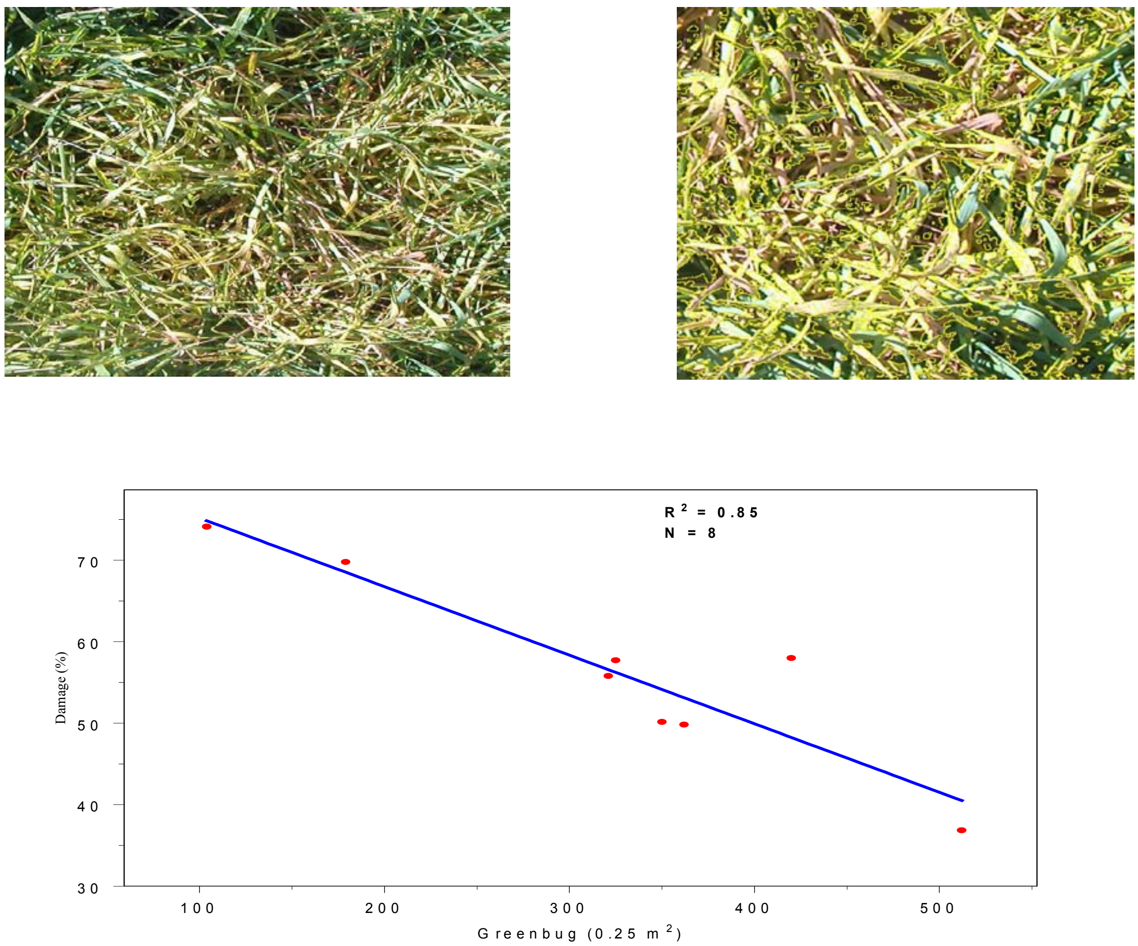


Figure 4: Greenbug-induced stress (upper left), estimation of damage caused by greenbug feeding (upper right), and the relationship between greenbug density and percentage damage (bottom) in wheat.

In order to investigate the relationship between aphid density and spectral data, 25 vegetation indices were calculated from reflectance data and regressed against aphid density. Very good to strong correlations explained by the R^2 values were found. The relationships explained by the R^2 values, spectral vegetation indices used to predict aphid density, and wavelength centers used to calculate spectral vegetation indices are given in Figure 5.

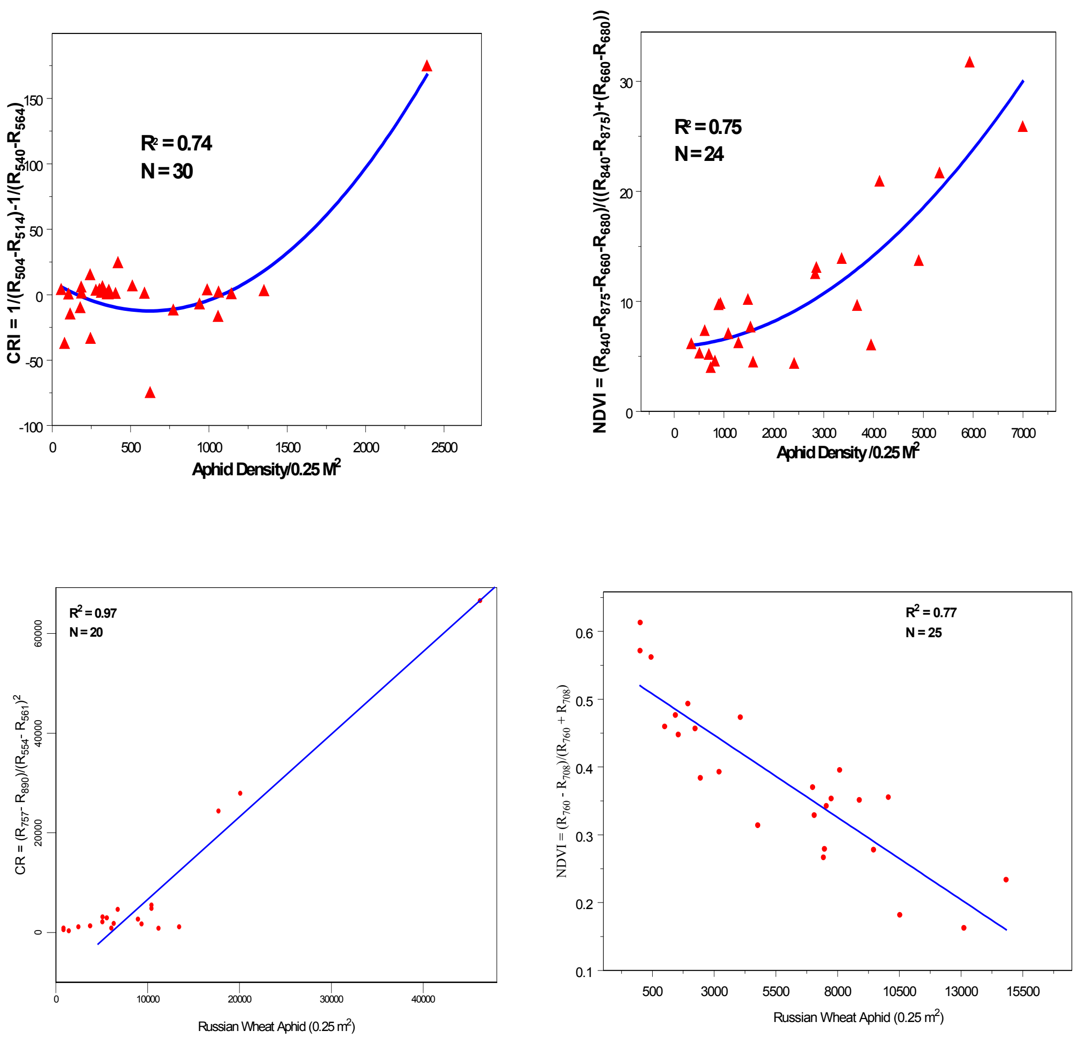


Figure 5: Plots of non-linear regression for aphid density (greenbug + bird cherry-oat aphid) and spectral vegetation indices (first two) and linear regression for Russian wheat aphid (last two). Data in the first plot were collected in a volunteer wheat field near Dumas TX, in the second plot data were gathered in a planted winter wheat field near Oklahoma City, OK, in the third plot data were obtained in a wheat field near Amarillo, TX, and in the last plot data were collected in a wheat field near Lamar, CO.

In addition to aphid and remote sensing data analysis, this work also dealt with prediction and comparison of wet and dry biomass from Russian wheat aphid infested and non-infested wheat near Amarillo, TX. It can be seen in Figure 6 that wet and dry biomass from Russian wheat aphid-stressed wheat were significantly different from non-stressed wheat. This result was also observed by Riedell and Blackmer (1999) who found reduction in dry weight of wheat leaves caused by Russian wheat aphid feeding when compare to Russian wheat aphid free leaves.

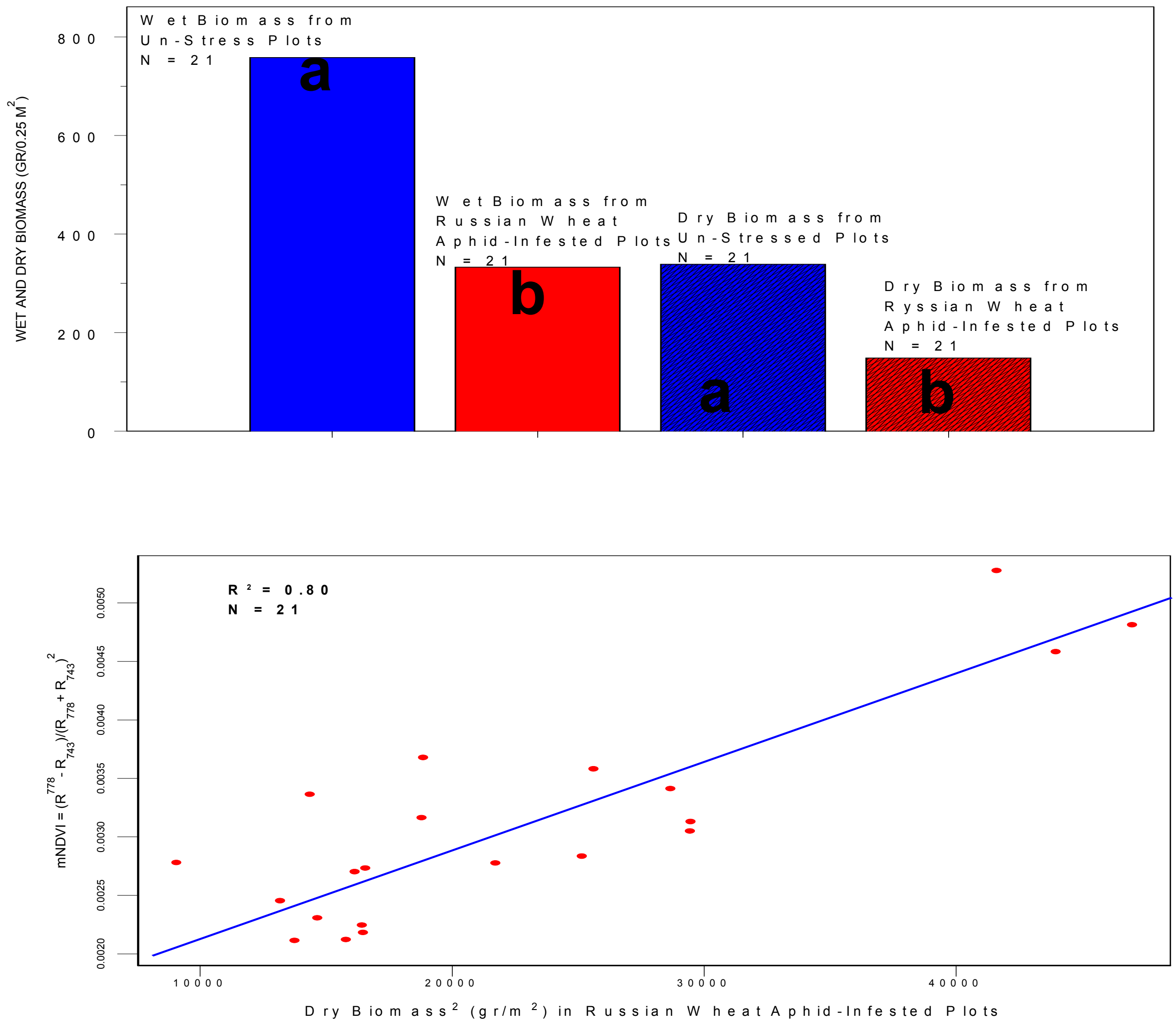


Figure 6: Dry and wet biomass from Russian wheat aphid-infested and un-infested plots (top) and the relationship between biomass gathered from Russian wheat aphid-infested plots and modified Normalized Difference Vegetation Index (mNDVI) (bottom).

CONCLUSIONS AND DIRECTIONS FOR FUTURE WORK

This work has shown that remote measurement of aphid-induced stress to estimate aphid density and separate the injured wheat from the healthy one at 0.25 m^2 canopy level in the field conditions was successfully employed.

Results reported in this work indicate feasibility of using remote sensing imageries at large scales to detect and discriminate aphid feeding damage in wheat and possibly in other crops.

We expect to work spectral measurements of interactions between aphid pest and host plants at larger scales using hyperspectral and multidate imageries.

Future work will continue to collect spectral data for aphid infestation on agricultural crops not only in the field conditions but also controlled environment.

Discrimination of three level of stress: water, nutrient, and aphid in wheat and sorghum will be the focus of the work in the near future.

Future work will also concentrate to develop and validate a spectral aphid stress index for major crops.

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ii. The search for a Distinct Spectral Signature for Greenbug and Russian Wheat Aphid Injured Wheat

Written by Zhiming Yang
Other Participants, Mahesh Rao, Norman Elliott, Dean Kindler, and Kris Giles.

Detection of Greenbug Infestation Using Ground-based Radiometry

Zhiming Yang

Challenges to detection

- Coexistence of water stress and greenbug infestation
- Confusion with infestation by Russian Wheat Aphid
- Timing issues in detection
  - Before greenbug density reaches maximum
  - Thresholds may be different at different growth stages

Principles of Stress Detection By Remote Sensing

- Leaf(canopy)reflectance
  - determined by leaf surface properties, internal structure, the concentration and distribution of biochemical components
  - most important: water and chlorophyll

- Canopy temperature – leaf transpiration

Research objectives

- To identify bands sensitive to greenbug infestation
- To identify vegetation indices sensitive to greenbug infestation
- Differentiating greenbug infestation with water stress and infestation by RWA
- To study impact of plant growth stage

Experiment facilities

Greenhouse and cropscan radiometer system

Sensors

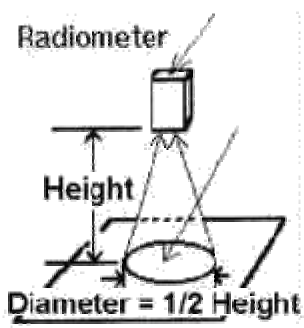
Data logger

CR-1O Weather station

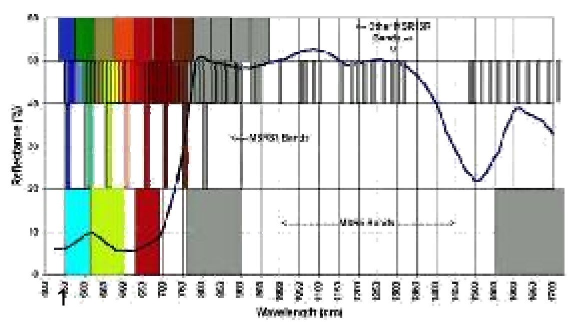
HOBO sensor

Soil moisture sensor

Operation and bands of Cropscan radiometers (MSR16R)



Field of view = 28°



Available bands for MSR16R

Band distribution for the Cropscan radiometer (MSR16R) in this study

Band name		Narrow (± 5nm)	Broad (>± 30nm)
Visible	Blue	1. 450	485
	Green	2. 580	560
	Red	620	660
		630	
		670	
		680	
		694	
NIR (Near Infrared)		800	830
		900	
		950	
MIR (Middle Infrared)		1480	1650

Experiment methods

- Planting:
  (1) Variety - TAM 107

  (2) Seed spacing 1in. x 3 in.
  (3) Plastic flats - 24 in. x 16 in. x 8.75 in (4)
  Soil - Redi-earth Plug and Seedling Mix (5)
  Pesticides – Marathon(1% granular)

- Infesting:
  (1) At two leaf stage, 15 days after sowing

  (2) Greenbug (biotype E), wingless adults (3)
  Density: 1 greenbug per plant

Experiment methods cont.

- Data collection
  - Reflectance measurements at nadir angle at noon time daily
  - Temperature and humidity using CR -10 or Hobo temperature and humidity sensor
  - Greenbug density (count GB on 10 plants and get average every three days)
- Plant Management
  - Fertilized once two weeks;
  - Watered 1-2 times a week.

Experiments conducted in this study

Treatments	Experiment Name	Sym-bol	Purpose	Time Periods
greenbug-infested without pesticide	Sensitivity experiment 1	SEex 1	Test sensitivities of band	Jan16 - Mar 12, 2002
non-infested with pesticide	Sensitivity experiment 2	SEex 2	and vegetation indices	Mar16 – May 1, 2002
control (non-infested without pesticide)	Sensitivity experiment 3	SEex 3		Nov 11 – Dec 24, 2003
greenbug-infested without water stress (NW+I)	Differentiating experiment 1	DIex 1	Differentiate greenbug infestation	Nov 5 – Dec 8, 2002
non-infested with water stress (W+NI)	Differentiating experiment 2	DIex 2	and water stress	Mar17 – Apr 13, 2003
control (non-infested without water stress) (NW+NI)	Differentiating experiment 3	DIex 3		Nov 11 – Dec 24, 2003
infested and water stress (W+I).				

Experiments conducted in this study (continued)

Treatments	Experiment Name	Sym-bol	Purpose	Time Periods
greenbug-infested at two-leaf stage	Stage experiment	STex	Test impact of growth stage	Jan 18 – Feb 26, 2003
greenbug-infested at tillering stage				
control (non-infested) at two-leaf stage				
control (non-infested) at tillering stage				
greenbug-infested	GB and RWA experiment	GRex	Compare two kinds of infestations	Oct 30 – Nov 20, 2003
Russian Wheat Aphid - infested				
control (non-infested)				

Data Processing and Analysis

- SAS program for repeated measures –
  PROC MIXED, PROC GLM
- Threshold Day and Maximum Day
  Threshold Day
  - the day subsequent to which there is always a significant difference between treatments;

  Maximum Day -
  the day at which greenbug density reaches maximum
- Correlation analysis –
  Correlation coefficients: differences in reflectance/vegetation indices vs. GB density
  – Significance test for correlation (p=0.05)

Data Processing and Analysis

- Sensitivity analysis (band and indices)

  $Sensitivity_{band}$= (Ref_{inf} – Ref_{ctrl})*100 / Ref_{ctrl} , where

  $Sensitivity_{band}$ – Sensitivity for a given band

  Ref_{inf} – Canopy reflectance of infested plants;

  Ref_{ctrl} – Canopy reflectance of control plants.

- Differentiating water stress and greenbug infestation: - Compare Threshold Day and Maximum Day
- Impact of growth stage on sensitivity of band or VI - Testing correlation and relative sensitivities
- Compare two kinds of infestations - Compare Threshold Day and Maximum Day

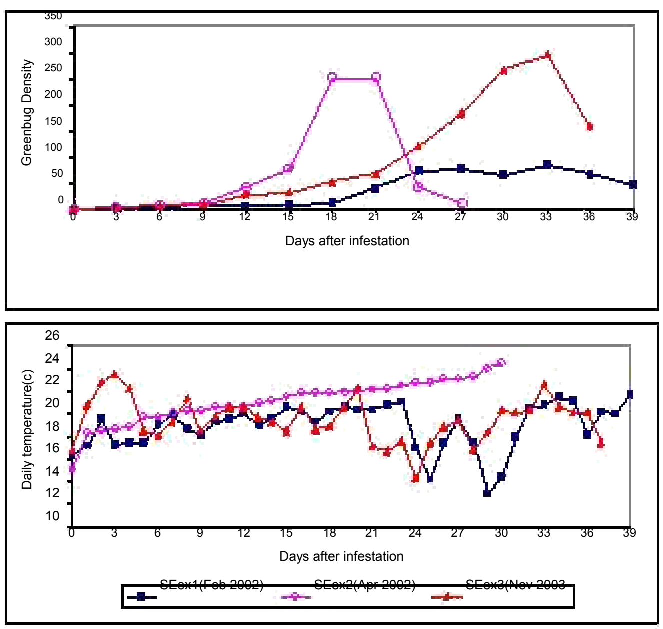
Vegetation indices used in various studies

Vegetation Index	Formula
Atmospheric Resistant Vegetation Index, ARVI (Kaufman and Tanre, 1996)	**ARVI = (NIR – (2red – blue))/(NIR + (2red – blue))**
Difference Vegetation Index, DVI (Tucker, 1979)	**DVI=NIR-Red**
Enhanced Vegetation Index, EVI (Verstraete and Pinty, 1996)	**EVI=(1+L) (NIR-red)/(NIR+C1*red - C2*blue+L) C1=6.0, C2=7.5, L=1.0**
Global Environmental Monitoring Index, GEMI (Pinty and Verstraete, 1992)	**GEMI=?(1-0.25?)-(red - 0.125)/(1-red)** **=[2(NIR^2-red^2)+1.5NIR-0.5red] /(NIR+red+0.5)**
Modified Soil Adjusted Vegetation Index Two, MSAVI2 (Qi et al., 1994)	**MSAVI2 =1/2 * [(2*(NIR+1)) - (((2*NIR)+1)^2 – 8 (NIR-red))$^{1/2}$]**
Optimized Soil Adjusted Vegetation Index, OSAVI (Rondeaux et al., 1996)	**OSAVI = ((NIR-red)/(NIR+red+L))*(1+L); L=0.16**
Normalized Difference Vegetation Index, NDVI (Rouse et al., 1973)	**NDVI=(band1-band2)/(band1+band2)**

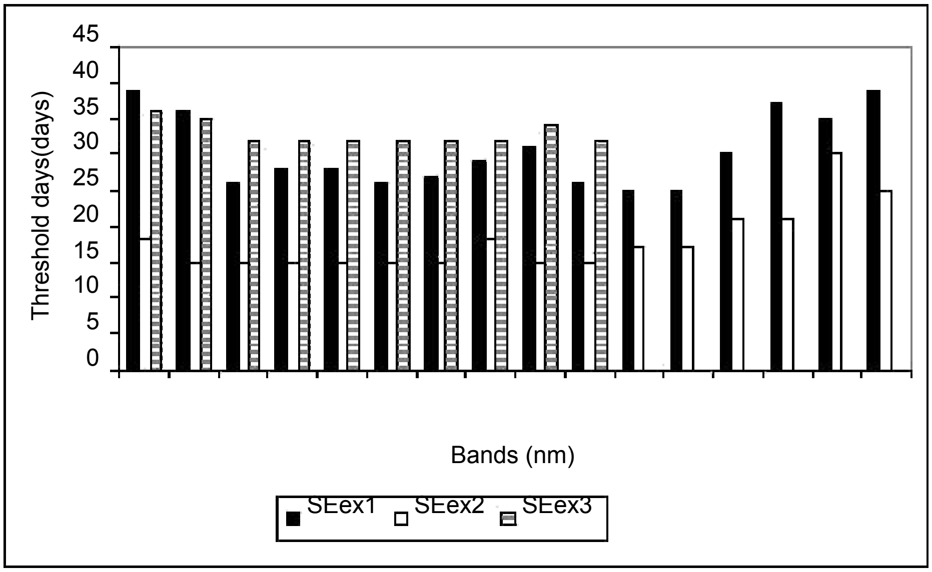
Vegetation indices used in various studies (continued)

Vegetation Index	Formula
Normalized total Pigment to Chlorophyll Index, NPCI (Riedell and Blackmer, 1999)	**NPCI = (R680-R430) / (R680+R430))**
Ratio Vegetation Index, RVI (Jordan, 1969)	**RVI=band1/band2**
Soil-Adjusted Vegetation Index, SAVI (Huete, 1988)	**SAVI = (1+L)* (band1-band2) /(band1+band2+L); L=0.5**
Structural Independent Pigment Index, SIPI (Penuelas and Inoue, 1999)	**SIPI=(R800-R450)(R800-R680)**
Specific Leaf Area Vegetation Index, SLAVI (Lymburner et al., 2000)	**SLAVI=NIR/ (Red + MIR)**
Vegetation Index One, VI1 (Viña, 2002)	**VI1=NIR/green -1**
Vegetation Index Two, VI2 (Viña, 2002	**VI2= R800/R694 -1**
Yellowness Index, YI (Adams et al., 1999)	**YI=(R580 – 2R630+R680)/?^{2}, ?=50 nm**
Water Band Index, WBI (Riedell and Blackmer, 1999)	**WBI=R950/R900**

Temporal changes in greenbug densities and daily temperatures



Threshold Days for bands



Maximum Days: 33(SEex1), 21(SEex2), 33(SEex3)

Correlation Coefficients and sensitivities of bands

Band (nm)	Correlation coefficient			Difference (%)#			
	SEex1	SEex2	SEex3	SEex1	SEex2	SEex3	Average
BAND560	0.7924*	0.9647*	0.9211*	20.29	36.49	31.68	29.49
BAND580	0.7104*	0.9632*	0.9310*	20.12	46.35	39.8	35.42
BAND620	0.6785*	0.9122*	0.8800*	21.76	67.42	28.76	39.31
BAND630	**0.7318***	**0.9459***	**0.8877***	**23.88**	**66.43**	**34.3**	**41.54**
BAND660	0.7701*	0.9039*	0.8741*	20.56	62.59	28.71	37.29
BAND670	0.6924*	0.9592*	0.9066*	17.65	55.09	32.29	35.01
BAND680	0.7804*	0.9480*	0.8373*	20.42	66.92	17.34	34.89
BAND694	**0.8288***	**0.9093***	**0.8992***	**22.85**	**73.79**	**30.31**	**42.32**
BAND800	-0.7271*	-0.9255*	0.1552?	-6.32	-19.59	-12.47	-12.79
BAND830	-0.7099*	-0.9313*	0.2272?	-5.27	-17.07	-9.49	-10.61

*: significant at 0.05 level; ?: not significant
#: Difference in reflectance between infested and control plants at Maximum Day

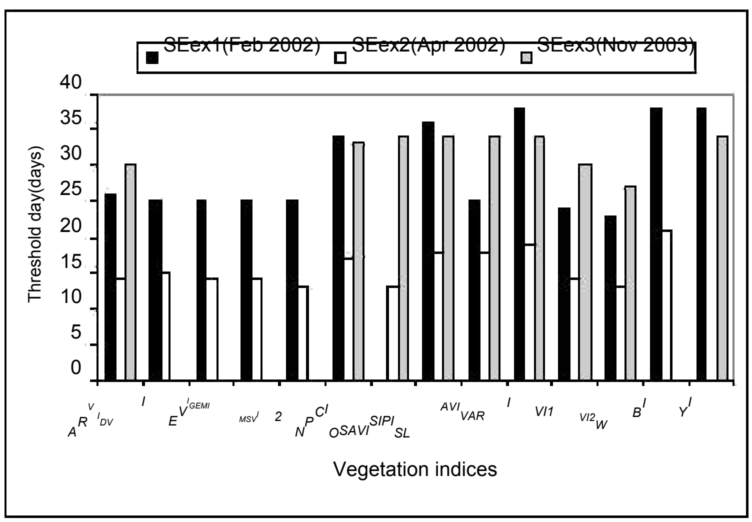
Most sensitive

Correlation Coefficients and sensitivities of selected VI

vegetation indices	correlation coefficients*		
	SEex1	SEex2	SEex3
NDVI_830_560	-0.7208	-0.9471	-0.8929
RVI_800_620	-0.7761	-0.96	-0.9511
RVI_800_630	-0.8089	-0.977	-0.9421
RVI_800_670	-0.7849	-0.9615	-0.9413
RVI_800_680	-0.8371	-0.9652	-0.9176
RVI_800_694	-0.8536	-0.9404	-0.9547
RVI_830_485	-0.7524	-0.9698	-0.8961
RVI_830_660	-0.8492	-0.9326	-0.9458
RVI_900_450	-0.8033	-0.9382	-0.7377
RVI_900_580	-0.7937	-0.9524	-0.8129
RVI_900_620	-0.7682	-0.9626	-0.8655
RVI_900_630	-0.8092	-0.9808	-0.8496
RVI_900_680	-0.8421	-0.967	-0.8438

Most sensitive

Threshold Days of Special Vegetation indices



Maximum Days: 33(SEex1), 21(SEex2), 33(SEex3)

Correlation Coefficients and sensitivities of some special vegetation indices

Vegetation Indices	Correlation coefficient			Difference (%) #			
	SEex1	SEex2	SEex3	SEex1	SEex2	SEex3	Average
EVI=(1+L) (NIR-red)/(NIR+C1*red - C2*blue+L)	**-0.4520**	**-0.7591***	**-0.4075**	**-8.28**	**-34.15**	**-22.51**	**-21.65**
ARVI = (NIR – (2red – blue))/(NIR + (2red – blue))	**0.1541**	**-0.7152***	**-0.8749***	**-9.09**	**-40.35**	**-27.87**	**-25.77**
MSAVI2 =1/2 * [(2*(NIR+1)) - $(((2*NIR)+1)^2$ – 8 (NIR-red$))^{1/2}$]	**-0.7377***	**-0.9140***	**-0.6319***	**-5.50**	**-18.39**	**-9.09**	**-10.99**
GEMI=?(1-0.25?)- (red - 0.125)/(1- red) | =[2(NIR^2-red^2)+1.5NIR-0.5red] /(NIR+red+0.5)	**-0.6088***	**-0.9042***	**-0.1881**	**-4.71**	**-18.42**	**-9.56**	**-10.90**
DVI=NIR-Red	**-0.5799**	**-0.9140***	**-0.1757**	**-9.14**	**-33.14**	**-19.53**	**-20.61**

Sensitive bands and vegetation indices

Band(nm)	Ranking	Vegetation indices	Ranking	Vegetation indices	Ranking
694	1	VI2_ 800_694	1	RVI_900_580	14
630	2	VI1_830_560	2	RVI_900_670	15
620	3	RVI_800_694	3	RVI_950_620	16
660	4	RVI_800_630	4	RVI_900_680	17
580	5	RVI_900_694	5	RVI_950_580	18
670	6	RVI_800_620	6	RVI_950_670	19
680	7	RVI_900_630	7	RVI_830_560	20
560	8	RVI_950_694	8	RVI_950_680	21
		RVI_800_670	9	RVI_830_485	22
		RVI_900_620	10	RVI_800_450	23
		RVI_830_660	11	RVI_900_450	24
		RVI_950_630	12	NDVI_830_560	25
		RVI_800_680	13	RVI_950_450	26
				MSAVI2	27

Most sensitive

Differentiating greenbug infestation and water stress

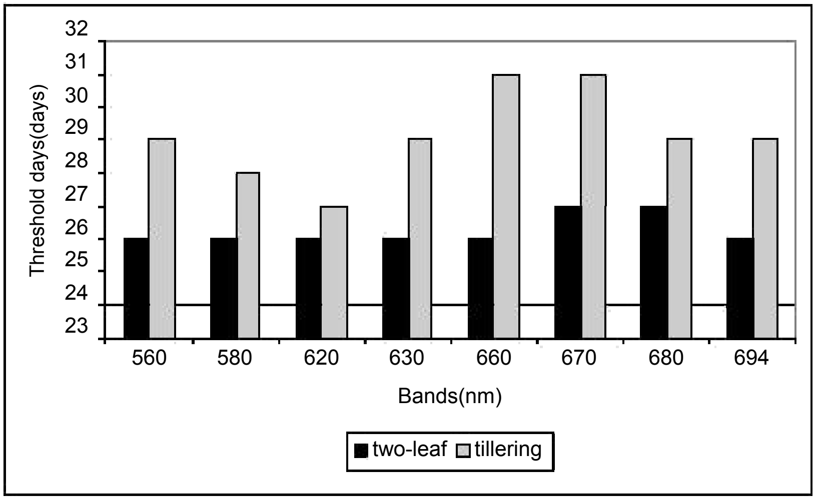
	Threshold Days		
Band (nm)	DIex1(Nov 2002)	DIex2(Mar 2003)	DIex3(Nov 2003)
560	no	27	28
580	no	24	31
620	34	27	32
630	34	27	32
660	32	27	34
670	32	27	36
680	34	27	35
694	34	27	34
Maximum Day	18	21	33

Note: there are no Threshold Days

Threshold Days of Selected VI used to differentiate water stress from infestation

Vegetation indices	DIex1(Nov 2002)	DIex2(Mar 2003)	DIex3(Nov 2003)
NDVI_830_560	17	27	31
RVI_800_450	no	25	31
RVI_800_694	18	22	28
RVI_830_485	30	25	33
RVI_830_660	18	22	29
RVI_900_620	17	27	28
RVI_900_630	18	27	28
RVI_900_680	17	24	28
RVI_900_694	18	21	28
RVI_950_670	21	27	28
RVI_950_680	20	24	28
RVI_950_694	18	21	28
VI1_830_560	17	26	31
VI2_800_694	18	22	28
MSAVI2	21	28	no
Maximum Day	18	21	33

Impact of stage on detection for bands



Comparing aphid infestations

Band(nm)	GB-Control	RWA-Control	GB-RWA
560	14	13	no
580	14	13	no
620	15	13	no
630	15	13	no
660	17	9	no
670	17	13	no
680	17	13	no
694	15	13	no
Maximum Day	18	18	

note: there are no Threshold Days
GB-Control: comparison between plants infested by GB and control plants;
RWA-Control: comparison between plants infested by RWA and control plants; GB-RWA: comparison between plants infested by GB and plants infested by RWA;

Threshold Days of Select VI Used to compare two kinds of infestations

Vegetation indices	GB-Control	RWA-Control	GB-RWA
RVI_800_450	18	9	9
RVI_800_620	15	9	no
RVI_800_694	16	9	20
RVI_900_670	16	11	20
RVI_900_680	16	9	20
RVI_900_694	15	11	19
RVI_950_450	18	9	9
RVI_950_580	14	9	19
RVI_950_620	14	9	20
RVI_950_630	15	9	19
RVI_950_694	15	9	19
VI1	14	9	no
VI2	16	9	20
MSAVI2	16	9	no
NPCI	16	no	16
YI	17	no	14

Sensitive bands

Band (nm)	Differentiate W and I	Stage impact	Differentiate G & R	Sensitive bands(?)
694	v	#	x	*
630	v	#	x	*
620	v	#	x	*
660	v	#	x	*
580	x		x	
670	v		x	
680	v	#	x	*
560	x		x	

W: water stress, I: Infestation, G: greenbug infestation, R: infestation by RWA
v: can be used, x: cannot be used, : #: can be used at both stages, *:sensitive band

Conclusions

- Sensitive bands:
  (Visible Red) 620, 630, 660(broad), 680, 694 nm

- Sensitive vegetation indices:
  VI2_800_694, RVI_800_694, RVI_950_694, RVI_950_620, RVI_900_680, RVI_950_680

- Landsat TM bands and derived vegetation indices such as VI1_830_560 could be used to detect aphid infestation.

- It is possible to detect greenbug infestation using sensitive bands or vegetation indices determined in this study.

Future research needs

- Hyper-spectral study using ASD spectrometer (350-2500 nm) at 2 nm resolution

- Differentiate greenbug infestation with nutrient deficiency and plant diseases

- Field studies to test sensitive bands and vegetation indices

- Investigate the unique spatial patterns caused by greenbug infestation

- Developed detection method by remote sensing to an effective decision tool for farmers

iii. Aircraft Based Russian Wheat Aphid Remote Sensing

Written by Thomas Dvorak, University of Iowa, Iowa City, IAOther Participants, Mustafa Mirik, Gerald J. Michels Jr., Norman C. Elliott, Sabina Kassymzhanova-Mirik, Roxanne Bowling, Vanessa Carney, Lana Castleberry, Johnny Bible, Bob Villarreal, Joy Newton, Denial Jimenez, Vasile Catana, Timothy D. Johnson

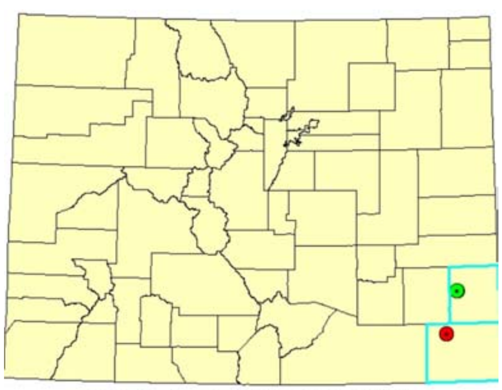
Introduction. The Russian wheat aphid is a serious threat to small grains including wheat and barley. Early detection of the pest is essential for management strategies including pesticide application. Due to environmental concerns and the small profit margin associated with small grain production, the decision to use an insecticide during a pest outbreak is crucial to farmers (Royer, Giles and Elliott 1998). With timely and precise detection of Russian wheat aphid presence, pest control measures could be carried out in a way that reduces economic losses and environmental impacts (Yang et al., in press). The purpose of this project is to examine multi-spectral remote sensing for its utility in detecting Russian wheat aphid infestations in wheat fields.

Background. The Russian wheat aphid is not native to the United States. The first US specimen was found in March of 1986 in the Texas panhandle. The Russian wheat aphid is small (< 1/10 inch) and greenish to grayish green. The shape of the insect is distinctive. It is more elongate than other aphids and the antennae and cornicles are short. Population explosions of Russian wheat aphids cause a speedy progression of crop damage in infested fields. Under heavy infestations, severe yield reductions of up to 100% are possible, and grain test weights can be reduced to only 20 percent of normal (Hein et al 1998).

Objectives.

- Use remote sensing to detect the presence of Russian Wheat Aphids in field plots.
- Examine the relationship of mean Normalized Difference Vegetation Index (NDVI) and density of aphids in each test plot.
- Determine if remote sensing is capable of differentiating stresses caused by drought and the Russian Wheat Aphid.

Study Area. The study area was located in southeastern Colorado in Baca and Prowers Counties (see figure on left below). One wheat field was examined in each county. It is important to note that these wheat fields were already under some drought stress in addition to the Russian wheat aphid presence (see figure below to right). Each field had 24 3x3 meter plots. White towels were laid down in the field to locate the plots in the image. They appear as small white dots in the image. Twelve plots were located in highly infested parts of each field, and 12 plots were located in less infested parts. Aphid density was determined for each plot. Immediately after sampling the plots for Russian wheat aphids, remote sensing imagery was obtained using a multi-spectral imaging system called the SSTCRIS. With these data, we could compare aphid density for each plot with reflectance intensity in remote sensing imagery for the plot.



Study Area (Wheat Fields)

- Grower #51
- Grower #53

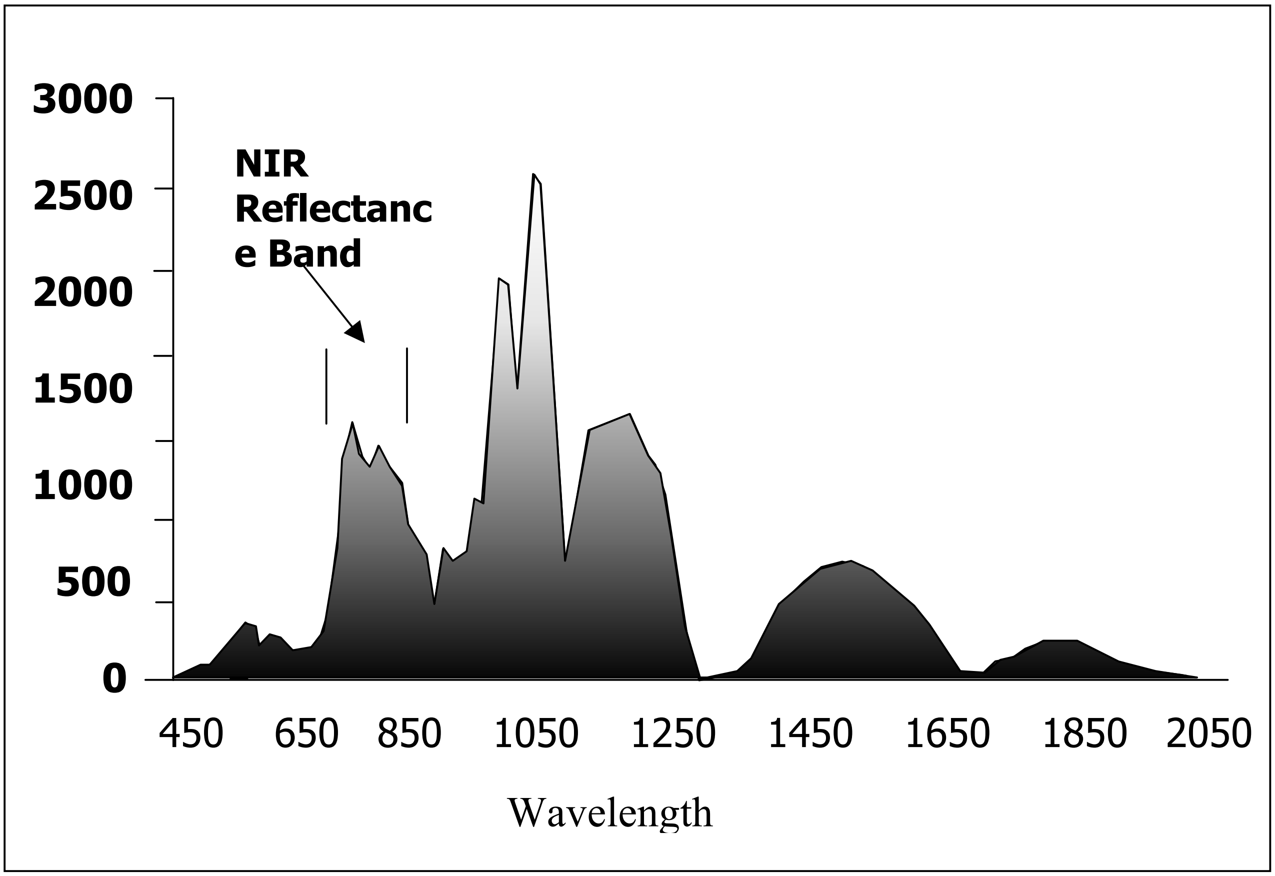
False color composite of study area in the Gower #53 field demarcated by four tarps.

Plant Stress and NDVI. When Russian wheat aphids feed on a plant and the plant becomes damaged, the plant is stressed. Plant stress is the deviation from the optimal conditions for growth, and could cause harmful effects when the threshold of the plants' ability to compensate is reached (Larcher 1995). Plant stress can occur due to water deficiency, nitrogen deficiency, insect infestation, disease, and other causes.

The Normalized Difference Vegetation Index is a commonly used and effective way to detect plant stress. The near-infrared band and red band of remotely sensed images are used to calculate NDVI.

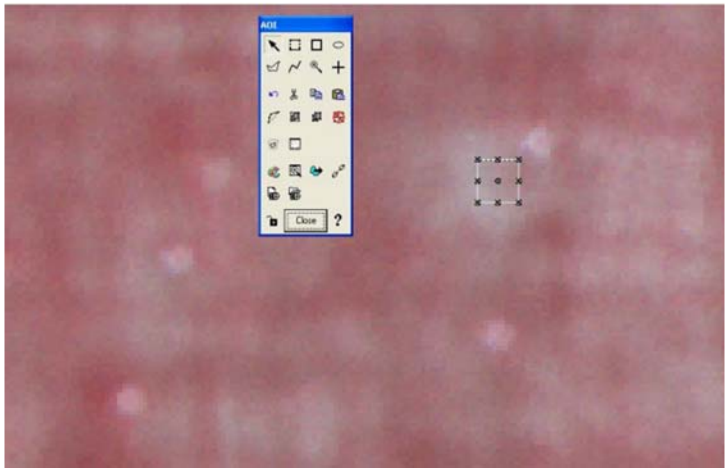
$$NDVI=(NIR-red) / (NIR+red)$$

Plants under stress show a decrease in reflectance in the NIR spectrum and reduced absorption of light in the photosynthetic spectrum (Shibayama et al. 1993). Due to these properties, reflectance can be used to assess stress levels in plants (Fernandez et al. 1994) (see figure below).



Methods

- Re-project images to the UTM Nad 83 zone 13 north coordinate system using ERDAS Imagine 8.6 software. Georeference the aerial remotely sensed images to the point layer of tarp and towel locations using ERDAS Imagine 8.6.
- Use towel point layer to identify correct locations of plot corners.
- In ERDAS, create AOI's (areas of interest) of 2x2 meter plot area one meter SW of the towels used to mark the NE plot corner. This was done for all 48 plot locations in the Grower #51 and Grower #53 fields (see figure below).
- Create subsets for each plot from AOI areas in ERDAS.
- Convert all pixels within each subset to a spreadsheet format from which to calculate mean NDVI for each plot.



Results and Conclusions. We have shown that multi-spectral remotely sensed data was sensitive to variation in the density of Russian wheat aphids in production wheat fields. Both fields studied showed lower NDVI values for highly infested plots than for less infested plots (see figures on next page). Despite the fact that the fields were drought stressed, Russian wheat aphid presence could still be identified using the NDVI values for each plot. The Grower #51 field showed a high coefficient of determination (.69) between Russian wheat aphid density and NDVI. Lower NDVIs were found in plots with higher Russian wheat aphid densities indicating that the additional stress caused by Russian wheat aphids in the drought stressed field was evident in the imagery. The Grower #53 field was not as heavily infested with Russian wheat aphids and that may explain the lower coefficient of determination (.44). Results of this study were encouraging, and indicate that further research is warranted to determine whether multi-spectral remote sensing can be used for detecting Russian wheat aphid infested fields in operational pest management programs for the pest.

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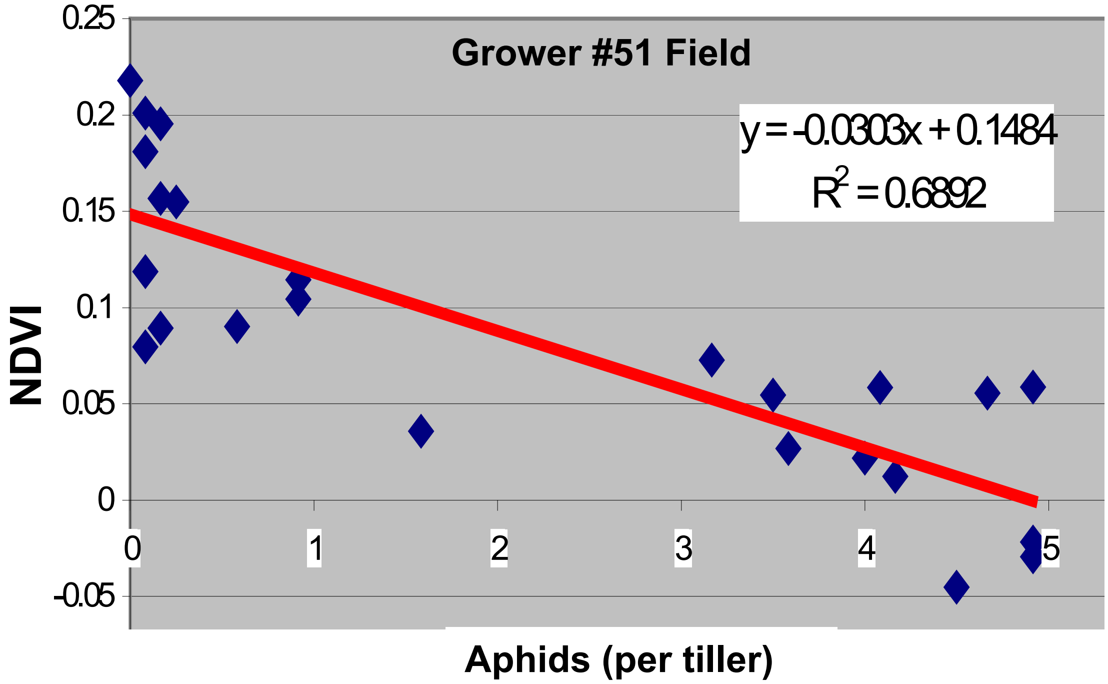
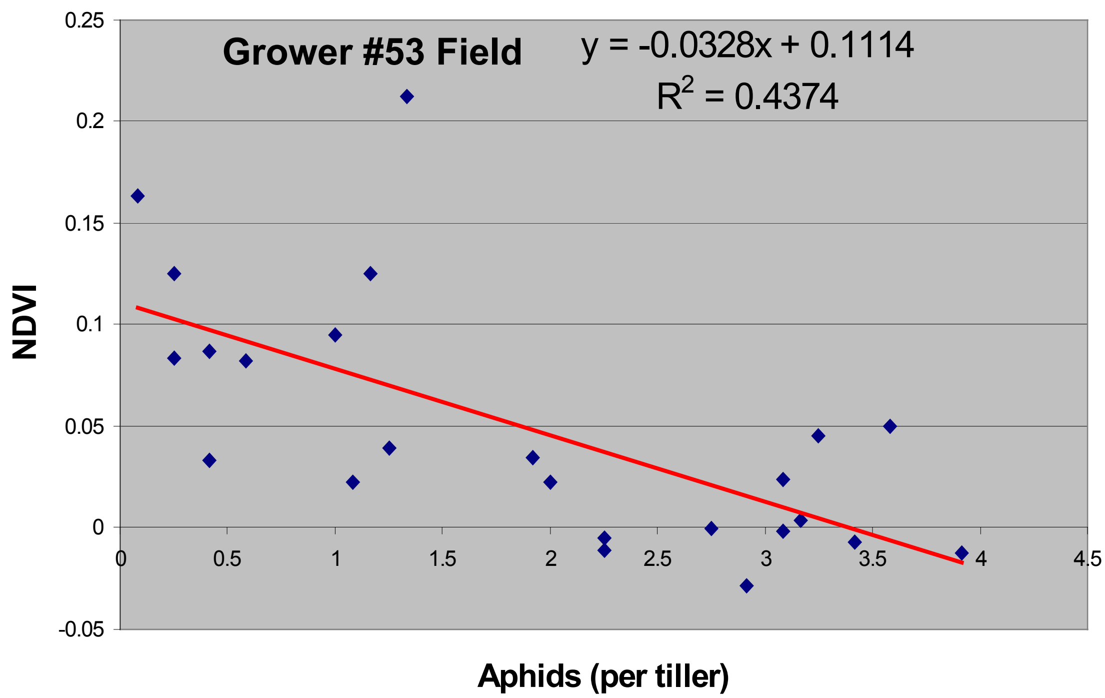

Grower #51 Field
y = -0.0303x + 0.1484
R2 = 0.6892
NDVI
Aphids (per tiller)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
1
2
3
4
5


Grower #53 Field
y = -0.0328x + 0.1114
R2 = 0.4374
NDVI
Aphids (per tiller)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

b. Natural Enemy Dynamics in Diversified Cropping Systems

i. Field evaluation of natural enemy dynamics in diversified and continuous wheat and soghum cropping systems.

Written by Mpho Phoofolo
Other Participants, Amber Kelly, Kris Giles, Norm Elliott, Dean Kindler, and Tom Royer

INTRODUCTION. The strategy of crop production through intercropping is viewed by many as a cornerstone for sustainable agriculture (Vandermeer 1989; Altieri 1994; Sullivan 1998). One of the benefits of intercropping is low insect pest pressure in production systems. Low insect pest pressure is an outcome attributed to factors explained by two hypotheses: the "natural enemy hypothesis" and the "resource concentration hypothesis" (Root 1973; Andow 1991).

The natural enemy hypothesis is based on the efficiency of predators and parasitoids in controlling herbivore populations in natural ecosystems. Natural ecosystems are typically characterized by spatial and temporal resource stability whereas resources in agroecosystems, dominated by monoculture, are ephemeral (Wiedenmann & Smith 1997). The ephemeral nature of resources is assumed to curtail the efficiency of natural enemies in monoculture production systems. Therefore, intercropping strategies, that ensure the spatial and temporal availability of resources to natural enemies, are considered to have pivotal components of sustainable insect pest management programs.

The objective of this study is to determine the potential of relay intercropping in enhancing natural enemy activities within the cereal production system. The goal is to determine how the mix of crops influences populations and communities of aphids and their associated natural enemies at the field scale. Preliminary results from this on-going study are reported.

MATERIALS AND METHODS. This study is being conducted at two sites, Perkins, OK and Chickasha, OK, and each site divided into nine plots. Three of the nine plots are diversified crops (40 x 160 ft strips of alfalfa, wheat, sorghum, and cotton), three are wheat monocultures (160 x 160 ft), and the remaining three are sorghum monocultures (160 x 160 ft). Each of these plots was randomly located within a 10.2 acre field. The plots are separated by 40 ft alleys that are kept fallow at all times. September 2003, plots were laid out at both study sites, during which alfalfa and wheat were planted in randomly selected areas [Note: sorghum and cotton will be planted in late spring and summer 2004, respectively and thus are not included in the results].

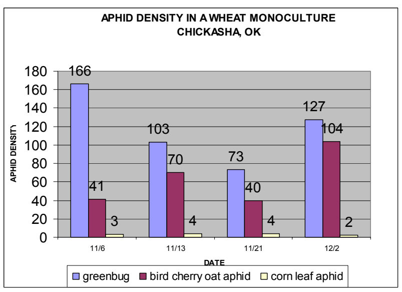
Predator Sampling: Random placement of a 0.5 m^2 quadrat (= a metal ring [80 cm diam. by 20 cm high]) in 4 random locations per plot followed by vacuuming each quadrat for 1.5 minutes with a suction sampler (Poulan PRO®). [Note that for monoculture plots only designated plot areas equivalent in size to diverse strips are sampled.] Density of predators is determined from counts per suction sample.

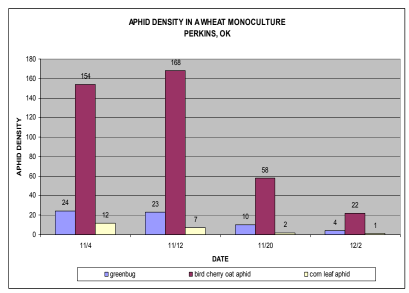
Densities reported are from 3 sampling dates for Chickasha (11/13/03, 11/21/03, and 12/02/03) and two sampling dates for Perkins (11/21/03 and 12/02/03). Yellow Pherocon® AM sticky traps mounted (stapled) on wooden stakes (2 ft above ground) so that the trap has two surfaces, east-facing and west-facing. Reported densities are from 2 sampling dates, 11/21/03 and 12/02/03, for each site.

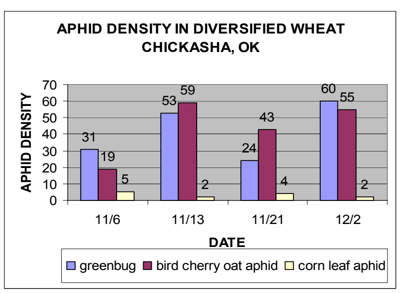
Aphid Sampling: A random selection of 100 tillers per wheat plot and a total of 50 stems per alfalfa plot was collected to determine aphid species density. Each tiller/stem was cut at ground level, placed in a labeled bag until sorting and identification. Collected aphids were identified to species and enumerated. Mummies were counted and aphids dissected to determine percent parasitism, however, parasitism data are not included in the results.

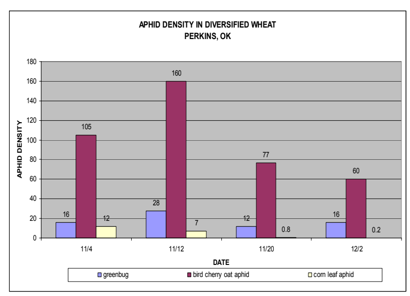
Analysis: Predator and aphid densities were statistically analyzed using a one-way analysis of variance, with monoculture wheat, diverse wheat, and alfalfa as factors. The analyses were done separately for each sampling date for each site.

RESULTS AND DISCUSSION. Aphid population densities (of individual species and the total number of co-occurring species) did not show any clear temporal pattern in Chickasha wheat plots (see figure below). This was unlike the situation in Perkins where densities of bird-cherry oat aphids (BCOA) were higher during early November. Furthermore, BCOA was the most abundant aphid in Perkins whereas this was not the case in Chickasha, where greenbugs were as abundant as BCOA. In terms of the comparison between aphid densities in wheat monoculture and diverse wheat, differences were only apparent in Chickasha where the wheat monoculture plots harbored more aphids in three out of four sampling dates. Although we did not statistically compare aphid densities between alfalfa and wheat it appears as though both wheat plots tended to have more aphids than alfalfa. The spotted alfalfa aphid was, in most cases, the only species found in alfalfa.









Population densities of many predators in Chickasha were relatively low across crop types during all three sampling dates (Table 1). For example, lady beetles like *Coleomegilla maculata* and *Coccinella septempunctata*, that are normally common in crops, were totally absent. Lady beetle larvae were actually found more often than the adults in suction samples. The most abundant predators in Chickasha were anthocorids (*Orius* spp.), anthicids, and spiders. Anthocorids were found almost exclusively in alfalfa. Anthicids and spiders were also significantly more abundant in alfalfa than in both diverse and monoculture wheat plots.

Table 1. Numbers of predators caught on Chickasha sticky traps

CROP	Convergent l. beetle	Seven-spotted l. beetle	Pink-colored l. beetle	Rove Beetles	Green lacewings	Hover flies	Spiders
	PREDATORS						
	DATE: November 25 / December 02						
Monoculture Wheat	0.1 / 0.1	0 / 0.03	0.1 / 0.1	0 / 0.6	0.9 / 1.2	1.3 / 2.6	0.2 / 1.8
Diverse Wheat	0.1 / 0.2	0.03 / 0.03	0.1 / 0.2	0 / 0.6	0.6 / 0.9	1.0 / 2.4	0.2 / 2.4
Alfalfa	0.1 / 0.1	0.03 / 0.08	0.2 / 0.2	0 / 0.9	0.9 / 0.9	1.6 / 3.1	0.1 / 2.2

In Perkins plots, population densities of most predators were also relatively low across the crop types and dates, with many averaging <1 per 0.5 m2 quadrat. Exceptions to this trend were found in anthocorids, staphylinids, anthicids, and spiders all of which occurred in significantly higher densities in alfalfa. Differences between diverse and monoculture wheat were significant only in the November densities of Anthicids. The occurrence of more predators in alfalfa than in the two wheat systems is an interesting outcome, especially given that the aphid density situation is quite the opposite.

Table 2. Numbers of predators caught on Perkins sticky traps.

CROP	Convergent l. beetle	Seven-spotted l. beetle	Pink-colored l. beetle	Rove beetles	Green lacewing	Hover flies	Spiders
	PREDATORS						
	DATE: November 25 / December 02						
Monoculture Wheat	0.03 / 0.06	0.03 / 0.03	0 / 0.03	0 / 0.7	0.9 / 0.9	6.6 / 17.8a	0.1 / 1.0
Diverse Wheat	0.03 / 0.06	0.03 / 0.03	0 / 0.03	0 / 0.4	0.7 / 0.7	7.9 / 19.5ab	0.06 / 0.6
Alfalfa	0 / 0.03	0 / 0	0 / 0	0 / 0.3	0.8 / 0.8	8.8 / 23.3b	0.03 / 1.0

Hoverflies were the only group of predators that appeared in relatively high numbers on the sticky traps. This was particularly the case in Perkins, where >20 flies per trap were found. It is important to note that there were very low densities of hoverfly larvae in the suction samples (Table 2). This implies either low reproductive activity during the sampling period or that the adults were not resident in the plots but only got attracted to the yellow color of traps.

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ii. An evaluation of how Coccinellids deal with the starvation that likely occurs in the field during transitions among crops in a diversified cropping system.

Written by Mpho Phoofolo
Other Participants, Kris Giles and Norm Elliott

How do coccinellids deal with nutritional stress?

MW Phoofolo[1], NC Elliott[2] & KL Giles[1]

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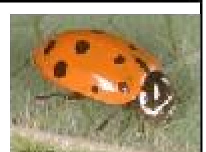
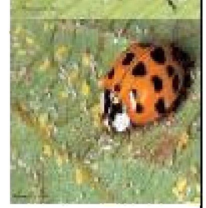


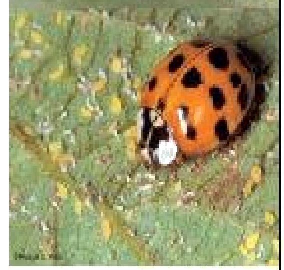
- Nutritional stress is a common phenomenon among insect predators, including coccinellids

Evidenced by

- field observations
  - Lack of co-occurrence of coccinellid larvae and prey spp. on plants
  - Intra-guild predation, cannibalism, and omnivory are feeding behaviors that indicate nutritional stress
- Large variation on body sizes of field collected adult coccinellids

Objectives

- Determine how*Hippodamia convergens*, *Colleomegilla maculata*, and *Harmonia axyridys* respond, in terms of their life history traits, to nutritional stress (starvation)
- Determine existence of threshold weight for metamorphosis in the three species



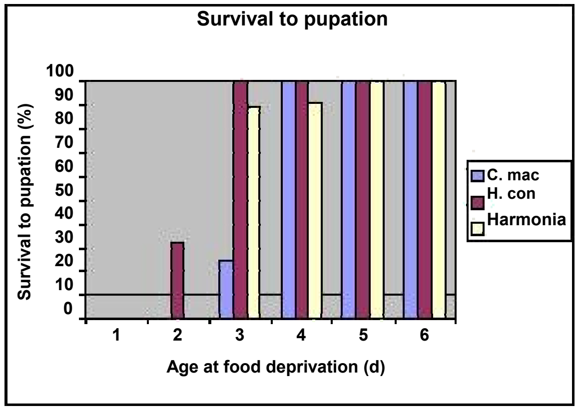
Fitness traits evaluated (at 22° C, L16:D8)

- Survival to pupation
- Age at metamorphosis
- Body size at metamorphosis
- Length of pupal stadium
- Adult size

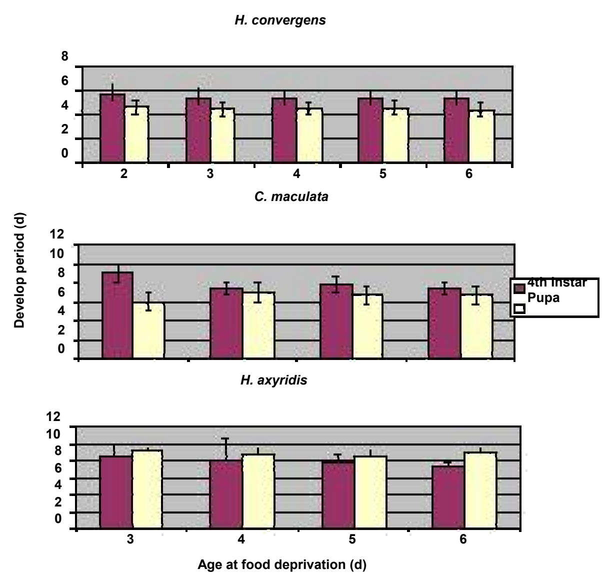
Stage subjected to different levels of nutritional stress = 4th instar

Study design

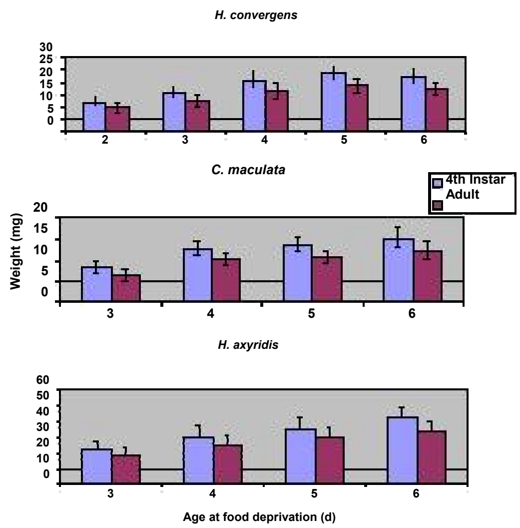
Age at food deprivation (d)	Feeding regimen of 4th instars
1	Starved throughout
2	Fed for 1 day only
3	Fed for 2 days
4	Fed for 3 days
5	Fed for 4 days
6	Fed for 5 days



Age at metamorphosis



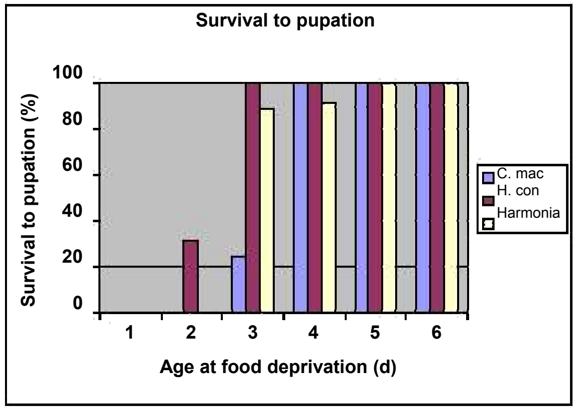
Size at metamorphosis



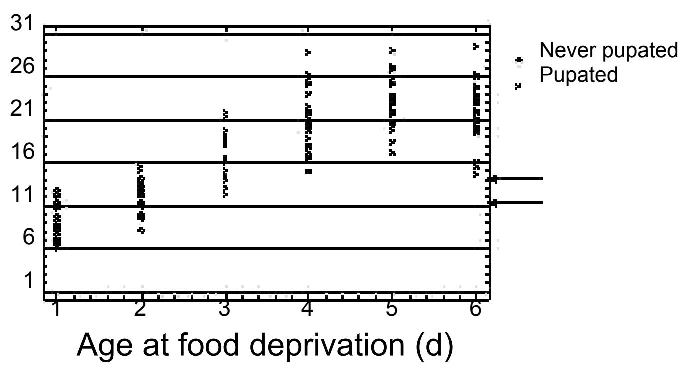
Coccinellids express:

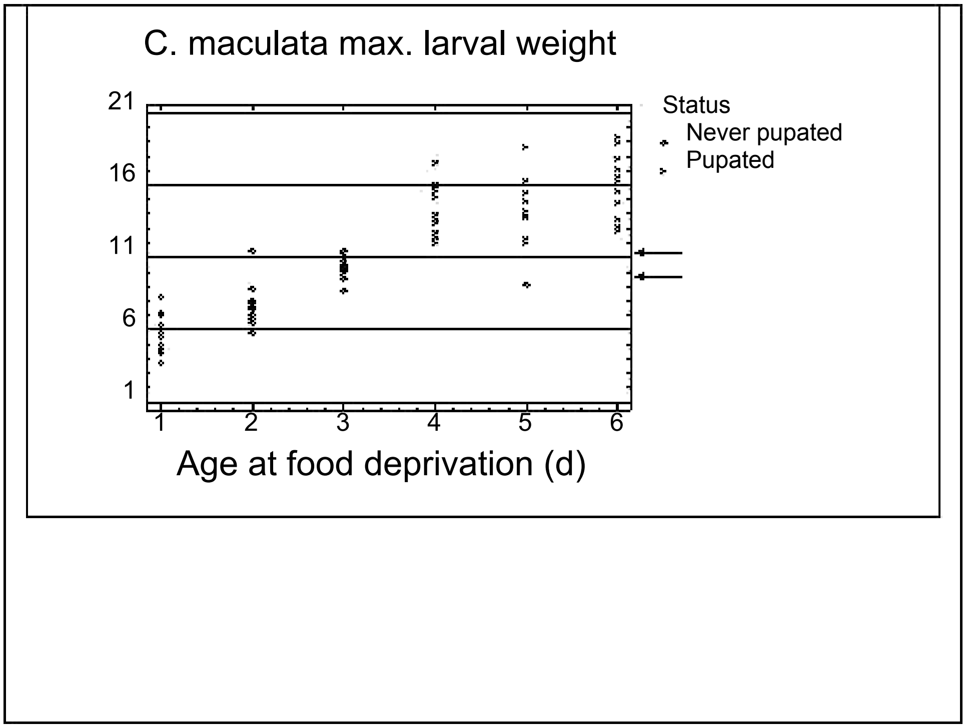
1. Developmental homeostasis or canalization
   - In age at metamorphosis = development time
   - i.e., the case in which the same phenotype results regardless of environmental variation.
2. Phenotypic plasticity
   - In body size (larval size at metamorphosis and adult size)
   - i.e., the case in which a change in the phenotype that depends on the environment.

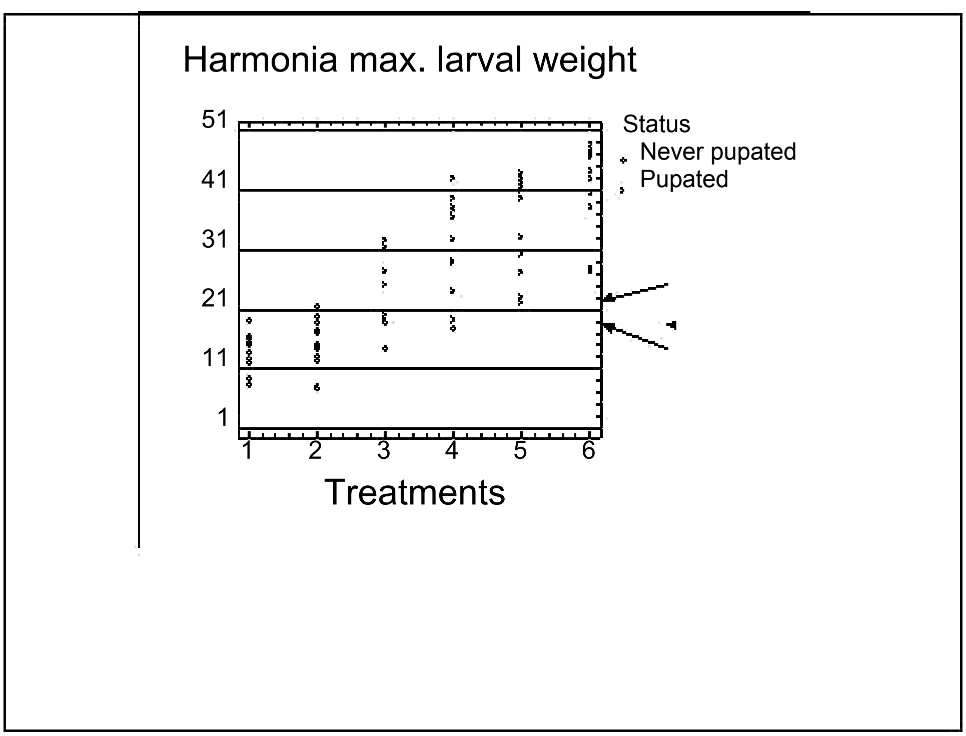
Is there a threshold weight for metamorphosis?



H. convergens max. larval weight




C. maculata max. larval weight
21
16
11
6
1
1
2
3
4
5
6
Age at food deprivation (d)
Status
Never pupated
Pupated


Harmonia max. larval weight
51
41
31
21
11
1
1
2
3
4
5
6
Treatments
Status
Never pupated
Pupated

Summary

- Coccinellids respond to nutritional stress by
  1. Maintaining the same development time
  2. Changing body size at metamorphosis and maturation

- Coccinellids display a threshold body size, below which further development is not possible (unless they are released from nutritional stress.

4. Education and Sociologic Evaluation Component Summary

Written by Paul Burgener, Dave Christian, and Sean Keenan

Overview

During the second year of Phase II for the Areawide program we completed our second cost of production interview with 146 growers participating in the project. Significant time was spent on data entry from first and second year interviews, particularly in the development of cost data entries and calculation methods. At the end of November 2004, cost data calculations are nearly 80 percent complete. Once completed, each grower will have a completed summary for each crop in our surveys.

For meeting project goals, cost production values will be used to develop comparisons by farm type, region, size, sate, and other critical variables. Additional analysis of survey questions, cost of production summaries, and integration with focus group findings from year 1 and year 4 will enable us to contribute toward educational goals of the Areawide project.

We also added a number of questions to our second year interview regarding wheat production practices, use of wheat for grazing, leasing arrangements for wheat pasture and other pasture, livestock leasing, and growers' use of computers and the Internet. Preliminary results from these and other survey question are examined in this second annual report.

Plans for the next year are to continue along the same path with an increased emphasis on the development of outreach components. Cost of production analysis will continue with another year of data and the initial results completed. Some of the key items to be completed in the next year include:

- Complete the calculations of year one and year two data for cost of production and analyze these results;
- Develop a plan for the final year focus group sessions and prepare for the analysis of this data on a short turn around time;
- Collect year three cost of production data and begin analysis for inclusion in final reports;
- Develop an increased outreach program and utilize additional opportunities to present information from this project at extension meetings;
- Prepare for significant outreach push through the fall and winter of 2005-2006 in conjunction with the focus group meetings to distribute information gleaned from the project.

Review of Participant Selection and Year 1 Accomplishments

During the first of four years of Phase II implementation of the Areawide program we: 1) recruited wheat producers from around the study region to participate in focus group discussions and cost-of-production interviews; 2) established procedures for the protection of human subjects and obtained necessary institutional approval; 3) conducted a total of twenty focus group discussions with participating growers; and 4) conducted the first of four annual cost-of-production interviews with each participant.

We selected participants in consultation with members of the project team, cooperative extension agents, local farm cooperatives, and wheat organizations in each state. As described in the Year 1 report, we sought participating growers representing both traditional wheat-fallow cropping systems and diversified cropping systems involving winter wheat. Overall, we sought growers who were similar in production characteristics to the growers who farmed the 23 Areawide project demonstration fields.

In Year 1, a total of 138 producers attended one of the twenty focus group discussions and we successfully completed interviews with a total of 146 wheat growers (including some who were unable to attend one of the scheduled focus groups). In Year 2, we successfully completed second year interviews with all but one of the 146 growers from the first year. The regional distribution of growers is illustrated in Table 1, along with a summary of counties where these growers have farm operations.

Table 1. Number of demonstration sites and number of growers participating in cost of production surveys by project zone and state (counties farmed from 2003 production interview)

Project zones	States	Demonstration sites	Number of growers	Counties farmed [a]
1	Wyoming	2	14	Goshen, **Laramie**, Larimer (CO)
	Nebraska	2	14	Cheyenne, **Banner**, Kimball, Morrill, **Scotts Bluff**, Laramie (WY)
	N. Colorado	2	18	Adams, Arapahoe, Logan, Morgan, Washington, **Weld**
2	S. Colorado	4	19	**Baca**, Bent, Cheyenne, Lincoln, Kiowa, **Prowers**, Hamilton (KS)
	Texas	5	26	Armstrong, Briscoe, Castro, Carson, **Deaf Smith**, Hartley, Hemphill, **Hutchinson**, Lipscomb, **Moore**, **Ochiltree**, Potter, Randall, Roberts, Sherman, **Swisher**, Beaver (OK)
3	Oklahoma	6	42	**Alfalfa**, Barber (KS), Blane, Garfield, Grant, Greer, Harmon, Harper (OK), Harper (KS), **Jackson**, **Kay**, Kiowa, Major, **Noble**, Tillman, Woods
	Kansas	2	13	**Reno**, Kingman
Total		23	146	

[a] Areawide field demonstration sites are located in counties with boldface type. We recruited growers recruited from these and surrounding counties.

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 growers 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. Numbers of counties farmed by participating growers are also influenced by the number of demonstration sites in each area, plus the geographical size of counties in each area (in particular, Texas and Oklahoma counties are smaller compared to other areas and more counties are represented in those states).

Progress toward economic cost-return summary reports

Cost of production results are taking shape with the completion of the cost data entry and calculations nearly 80 percent complete at the end of Year 2. With the completion of these calculations, the task of developing summary information for growers will begin (see example of summary in Figure 1). Each grower will have a completed summary for each crop and an overall summary for the dryland portion of the farm based on the data collected in our surveys.

The cost of production information will be used to determine the potential for increasing profitability by adoption of alternative cropping practices. In addition, the summary values calculated will be used to develop comparison data by farm type, region, size, state, and other critical variables. Analysis will be completed using data from specific cost and return data to evaluate the most profitable decisions and systems.

The data will also be used to make comparisons between the actual profitability of the farms and the decision making information gathered in the focus group sessions. The comparison of these two data sets will give us the unique opportunity to evaluate the profitability and decision making criteria as spoken, and determine where these growers may be making rational decisions or making decisions that are contrary to their goals.

The submission of a paper from this data is expected by early spring, for presentation in the summer of 2005. This will be the basis for an educational program over the next 18-24 month period. Additional data will be collected, so the educational program will be a dynamic process using the new data to improve the resulting program over the remainder of the project and beyond.

Areawide Pest Management for Wheat
Cost and Return Summary Report

Grower: 299
Crop: Wheat
Year: 2002

Actual Production Costs ($/Acre)		
Variable Costs		
Labor	1.30	
Fuel	2.61	
Repairs	1.69	
Seed	7.00	
Fertilizer	12.90	
Herbicide	0.00	
Custom	4.55	
Crop Insurance	4.50	
Overhead	1.73	
Operating Interest	1.84	
Total Variable Costs		**$37.66**
Ownership Costs		
Depreciation	0.27	
Interest	0.50	
THI	0.31	
Total Ownership Costs		**$1.08**
Total Production Costs		**$38.74**
Crop Acres	**4,000**	

Actual Revenue ($/Acre)		
Crop Revenue		
Wheat Yield	0	
Wheat Price	$3.00	
Total Crop Revenue		**$0.00**
Government Payments		
Direct Payment	8.40	
Counter Cyclical Payment	0.00	
Loan Deficiency Payment	0.00	
Total Govt. Payments		**$8.40**
Crop Insurance Revenue		
Wheat Indemnity (CRC)	41.25	
Total Crop Insur. Revenue		**$41.25**
Total Revenue		**$49.65**
Net Return to Land and Management ($/Acre)		**$10.91**
Total Return from Wheat		**$43,640**

Yielding Results by innovating & educating

Figure 1. Example cost-return summary for 2002 wheat production (we are currently developing similar reports for all dryland crops and all growers from 2002 and 2003 production interviews)

Acreage and livestock totals from 2003 crop production interview

Table 2 provides an illustration of growers' dryland crop acres, dryland pasture, and CRP acres for the 2003 crop year. Acres planted is important for cost of production assessments, along with additional questions regarding acres harvested and crop yields, not shown in the table. Tracking growers' planted acreage for dryland crops over the four year study period will assist us in evaluating crop rotations used with winter wheat. Forage production, pasture, livestock, irrigated acres, and CRP lands will be important to consider as we examine overall farm profitability and grower decision-making related to wheat and how it is used on these farms.

Collectively, growers had nearly 600,000 dryland acres for the 2003 production year, including nearly 199,000 of winter wheat, 87,000 acres of fallow, and nearly 89,000 acres of summer crops, hay, and forage. The remaining dryland acreage included 173,000 acres of dryland pasture and 52,000 uncultivated acres in the federal Conservation Reserve Program (CRP). In addition to these dryland acres, the growers had nearly 45,000 acres of irrigated crops and pasture, illustrated in Table 3.

Summer crops grown in rotation with winter wheat varied across the study region. Important summer crops among our growers in Wyoming, Nebraska, and Colorado were proso millet, sunflowers, corn, and millet for hay. Sunflowers and dryland corn were also important crops among some of the growers in Kansas, along with grain sorghum and soybeans. Soybeans were also an important dryland crop for some of the Oklahoma growers, while grain sorghum was clearly the predominant dryland summer crop among participating growers in Texas. Cotton was also an important dryland crop for some of the growers in Texas and Oklahoma.

Also evident in Table 2 is the importance of pasture, hay, and forage crops for many of our participating growers. Forage sorghum or Sudan grass for hay and forage is the most widely distributed summer crop over our entire study region. Millet is an important hay and forage crop among some of the growers in Wyoming, Nebraska, and Colorado. In Kansas, Oklahoma, and Texas, winter wheat is utilized for grazing and hay in addition to grain harvest or as an alternative to harvesting the crop for grain. Alfalfa is also an important hay crop for many of our growers, particularly in Kansas and Oklahoma.

As illustrated in Table 4, 82 of 144 growers we interviewed had cattle operations for 2003. **Collectively, growers totaled nearly 47,000 head of cattle for 2003**. Table 5 illustrates the importance of wheat used for cattle grazing and the importance of leasing arrangements related to cattle operations.

Table 2. Overview of dryland acres from 2003 crop production interview

	Acres planted by state:						All planted acres
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	
Winter wheat:							
Grain production only	14,146	8,813	69,312	8,960	25,695	12,432	139,358
Graze and grain	600	---	5,896	1,446	27,386	11,072	46,400
Graze only (graze out)	---	---	120	129	5,844	5,502	11,595
Cut for hay	---	---	--	30	1,329	100	1,459
Subtotal, all winter wheat acres	14,746	8,813	75,328	10,565	60,254	29,106	198,812
Fallow acres	15,412	8,372	53,557	128	191	9,190	86,850
Summer crops, hay, and forage: [a]							
Proso millet	1,468	7,231	9,543	---	---	---	18,242
Sunflowers	1,011	2,601	9,000	1,143	---	---	13,755
Corn	278	885	4,839	1,669	944	---	8,614
Millet, for hay and forage	217	339	1,730	101	34	---	2,421
Forage sorghum/Sudan grass for hay	200	40	1,815	383	1,414	451	4,303
Grain sorghum	---	---	6,095	4,520	2,539	7,692	20,847
Alfalfa	---	16	162	908	4,344	---	5,430
Soybeans	---	---	---	1,289	2,002	---	3,291
Cotton	---	---	---	---	1,957	3,775	5,732
Other cropland utilized for grazing (rye, sorghum, oats, millet)	---	---	398	124	725	156	1,403
Other grasses (for hay)	20	---	---	80	731	308	1,139
Rye (graze+grain/seed)	---	---	---	---	900	---	900
Other hay & forage crops (barley, oats, peas, triticale)	376	---	508	---	---	---	884
Oats	52	160	---	5	200	145	562
Mung beans	---	---	---	---	382	---	382
Spring wheat	---	---	---	235	---	---	235
Safflower	---	---	223	---	---	---	223
Barley	159	---	---	---	36	---	195
Peanuts	---	---	---	---	95	---	95
Triticale (grain, seed)	---	---	80	---	---	---	80
Sun hemp (no-till cover crop)	---	---	---	50	---	---	50
Chick Peas	40	---	---	---	---	---	40
Subtotal, summer crops, hay, and forage	3,821	11,272	34,393	10,507	16,303	12,527	88,823
All dryland pasture (native and improved)	15,908	24,129	46,511	5,493	44,424	36,152	172,617
Conservation Reserve Program (CRP)	5,377	5,902	31,123	875	3,251	5,397	51,925
Total dryland acres, all categories	55,264	58,488	240,912	27,568	124,423	92,372	599,027
Number of growers	14	14	37	12	42	25	144

[a] Summer crops, hay, and forage are partially ordered by acreage and by state to help illustrate regional distribution.

Table 3. Irrigated acres, 2003 crop production interview

	Irrigated crop acres by state						All planted acres
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	
Winter wheat:							
Grain production only	857	484	1,510	116	403	5,666	9,036
Graze and grain	--	258	645	347	--	2,841	4,091
Graze only (graze out)	--	--	--	--	280	498	778
Cut for hay	--	--	--	--	--	80	80
Subtotal, all irrigated winter wheat	857	742	2,155	463	683	9,085	13,985
Fallow	--	13	617	--	--	1,144	1,774
Summer crops, hay, and forage: [a]							
Corn	42	739	1,615	541	240	4,713	7,890
Cotton	--	--	--	--	811	4,255	5,066
Grain sorghum	--	--	568	--	260	2,986	3,814
Alfalfa	270	657	1,248	65	143	845	3,228
Sunflowers	102	284	608	--	--	1,249	2,243
Beans (dry, pintos)	795	123	165	--	--	--	1,083
Forage sorghum/Sudan grass (for hay & forage)	--	--	520	--	300	100	920
Other hay & forage crops (barley, oats, peas, triticale)	124	364	117	--	--	40	645
Soybeans	--	--	--	555	--	58	613
Millet (hay and forage)	70	364	132	--	--	--	566
Other cropland utilized for grazing (rye, sorghum, oats, millet)	--	--	125	149	--	271	545
Oats	98	149	--	64	--	--	311
Peanuts	--	--	--	--	290	--	290
Barley	--	60	100	--	--	--	160
Other grass (for hay)	124	15	--	--	--	--	139
Proso Millet	--	25	60	--	--	--	85
Sugarbeets	--	60	--	--	--	--	60
Pumpkins	--	--	50	--	--	--	50
Wheatgrass (for seed)	--	22	--	--	--	--	22
Beans (dry, yellow)	--	--	20	--	--	--	20
Peppers (Chili)	--	--	--	--	10	--	10
Triticale (grain, seed)	--	--	--	--	--	10	10
Subtotal, summer crops, hay, and forage	1,625	2,862	5,328	1,374	2,054	14,527	27,770
All irrigated pasture (native and improved)	120	240	--	130	800	--	1,290
Total irrigated acres	2,602	3,857	8,100	1,967	3,537	24,756	44,819

[a] Irrigated summer crops, hay, and forage ordered by total planted acres.

Table 4. Average cattle inventory for 2003 (totals for all growers by state)

	State						All growers
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	
Mother Cows	1,059	2,070	1,347	564	4,270	826	10,136
Replacement Heifers	86	480	230	128	428	86	1,438
Bulls	17	86	73	40	256	57	529
Raised Steers	188	1,031	1,365	268	1,907	182	4,941
Raised Heifers	166	1,006	1,316	281	1,880	326	4,975
Purchased Steers	10	1,070	799	81	3,512	4,919	10,391
Purchased Heifers	1,000	2,540	770	44	4,341	1,474	10,169
Other Cattle or Stockers	0	0	16	26	4,283	0	4,325
Total head	2,526	8,283	5,916	1,432	20,877	7,870	46,904
Number of growers with cattle	4	6	19	6	35	12	82
Growers without cattle	10	8	18	6	7	13	62
Total growers	14	14	37	12	42	25	144

Table 5. Use of wheat for cattle grazing, leasing of wheat or other pasture, and cattle leasing activity, 2003

	State						All growers
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	
<u>Cattle grazed on wheat, 2003</u>?							
No	13	13	34	5	12	15	92
Yes	1	1	3	6	30	11	52
Total	14	14	37	11	42	26	144
If yes, average days on wheat	--	--	96.67	63.75	102.52	135.00	102.23
Average cattle gain (lbs/day)	--	--	2.20	2.20	2.25	2.01	2.18
<u>Any wheat or pasture leased out for grazing in 2003</u>?							
No	9	7	22	6	26	12	82
Yes	5	7	15	6	16	14	63
Total	14	14	37	12	42	26	145
<u>Lease any cattle to graze, 2003</u>?							
No	14	13	36	11	35	24	133
Yes	--	1	1	1	7	2	12
Total	14	14	37	12	42	26	145

Wheat Varieties

Table 6 illustrates wheat varieties planted for the 2003 crop year. The wheat varieties planted by participating growers stayed relatively consistent for the 2002 and 2003 crop years, with a few notable changes (figures for 2002 crop are reported in our Year 1 report).

For the 2003 crop year, acres planted to the four Russian Wheat Aphid (RWA) resistant varieties were up by 15%. This will be a key factor to evaluate in the 2004 data after the discovery of a RWA biotype that is not affected by the RWA resistant wheat varieties. **The acres of TAM 110, which is greenbug tolerant, also increased more than 65% from 2002 to 2003 among participating growers**. Other varieties were similar with typical adjustments from variety to variety that would be expected given different weather conditions and the usual planting time decisions of growers.

One notable distinction is a dramatic increase in the number of acres planted to Trego, a hard white winter wheat, in 2003. The Trego planted increased from 1,599 acres in 2002 to 10,050 acres in 2003, a 528% increase from one year to the next. The federal white wheat program was not in place at planting time for the 2002 crop, but was known prior to planting the 2003 crop. This incentive increased the acres and the number of growers of white wheat throughout the region, and this survey reflects that increase.

Table 6. Most popular varieties of winter wheat for 2003 crop production year (number of acres planted and number of producers by state for varieties over 500 acres)

	Wyoming		Nebraska		Colorado		Kansas		Oklahoma		Texas		Project total	
Variety	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.
Jagger	10	1			2,361	3	6,678	11	30,552	35	3,835	6	43,436	56
Pioneer 2174							604	3	15,373	25	523	1	16,500	29
Akron	1,427	3	280	1	14,346	11							16,053	15
TAM 110*					2,046	2					13,930	13	15,976	15
Buckskin	12,110	12	2,161	5									14,271	17
Prairie Red*					13,367	12							13,367	12
Trego (white)					10,050	10							10,050	10
Pioneer 2137	255	1	562	1			1,219	3	2,976	6	4,876	7	9,888	18
Halt			100	1	8,567	8							8,667	9
Prowers 99*					5,731	6							5,731	6
Above					4,272	8							4,272	8
Alliance			2,772	7	1,446	3							4,218	10
TAM 107	57	1			1,005	1					2,317	2	3,379	4
Yumar*					2,776	6							2,776	6
Triumph 64											2,448	2	2,448	2
OK 101									2,159	8			2,159	8
TAM 105											2,152	4	2,152	4
Trio T13					2,110	1							2,110	1
Quantum					1,745	1							1,745	1
Hardman Grain 9									1,701	2			1,701	2
Coronado							1,245	3	233	1			1,478	4
Yuma					1,390	1							1,390	1
Dumas											1,342	6	1,342	6
Larned											1,306	1	1,306	1
Longhorn					160	1	79	1	800	1	200	1	1,239	4
TAM 200											1,182	1	1,182	1
Custer									1,178	3			1,178	3
Millenium	30	2	941	2									971	4
Triumph Early											966	1	966	1
Pioneer 2167											760	1	760	1
Scout					711	1							711	1
T81					691	2							691	2
Niobrara			686	1									686	1
Ogallala			341	1	100	1					186	1	627	3
Baca					584	1							584	1
Pioneer 2158									525	1			525	1
Jagalene	195	2					73	2	190	2	60	1	518	7
Vona			501	1									501	1

* Russian wheat aphid resistant varieties in boldface type; underlined variety (TAM 110) with greenbug resistance.

Wheat production practices and pest management

In the 2003 interview, we added a page of questions regarding growers' wheat production practices and pest management, including wheat seed cleaning, seed treatment, field recordkeeping, insect scouting, and observations of beneficial insects. Responses to these questions are illustrated in Tables 7 and 8.

As illustrated in Table 7, we observed that:

- **The majority of growers participating in our project practiced seed cleaning before planting winter wheat**. Most commonly, growers paid a custom seed cleaner to clean their seed (95 out of 145 growers). Custom rates for this service reported by growers ranged from 25 cents per bushel to $1.50, and averaged around 52 cents/bushel.
- **Seed treatment insecticides or fungicides for wheat were not widely utilized by the growers** (32 out of 145 growers did). Many did not consider this a necessary practice or found it to be cost prohibitive.
- **Soil testing at some regular interval was common among these growers**; 104 out of 145 used soil testing at regular intervals for at least some acres, though annual soil testing was not the norm.
- **Nearly all growers kept some type of field records** (such as planting dates, varieties planted, and field operations like tillage, fertilizer, insecticide applications). Most commonly, growers seemed to be keeping track of planting dates, which has become essential for crop insurance record keeping. However, we were not able to systematically assess the extent to which growers may or may not be utilizing record keeping as a crop management practice with this question. The most common type of record keeping was a journal, day planner, or calendar where field operations could be recorded. Often growers kept a journal in their tractor or pickup. Some grower's spouses kept a "backup" record on the kitchen calendar.
- **A total of 27 out of 145 growers kept at least some computerized field records**. Later in the interview we also asked about use of computers for farm financial record keeping. As illustrated in Table 9, 106 out of 145 indicated that they used a computer for some or all of their farm record keeping, where this included financial records. Here again, many spouses assisted in keeping computerized records for the farm.

Also illustrated in Table 7 is a summary of field tillage practices. We did not specifically ask about tillage practices, but determined these figures from our questions about field operations for each crop. The majority of participating growers practice limited tillage on some or all of their cultivated acres (104 out of all 146 participating growers). A total of 34 growers were practicing no-till on some or all of their crop acres. We have no-till growers distributed throughout the project study region, with larger numbers in Colorado and Oklahoma due to larger numbers of participants in those states.

Table 7. Wheat production practices

	State						
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	All
Wheat seed cleaning…							
Custom cleaned	5	8	24	9	36	13	95
Cleaned by seed dealer or purchased certified seed	4	1	3		2	6	16
Self cleaned	5	5	8	3	2	2	25
None			2		2	5	9
Total	14	14	37	12	42	26	145
Use any wheat seed insecticide or fungicide?							
No	13	13	32	9	32	14	113
Yes	1	1	5	3	10	12	32
Total	14	14	37	12	42	26	145
Use annual soil test(wheat fields)?							
None	8	10	7	1	2	13	41
At least some acres, periodically	6	4	30	11	40	13	104
Total	14	14	37	12	42	26	145
Keep records for individual fields (how kept)?							
Filed records (saved records, receipts only)	4	1	2		7	3	17
Some written record keeping (journal, calendar, notebook, field maps)	9	8	18	11	30	21	97
Some computerized field records	1	4	15	1	4	2	27
None specified		1	2		1		4
Total	14	14	37	12	42	26	145
Tillage Practices… [a]							
Conventional tillage, some use of moldboard plow	4	2	--	2	6	--	14
Conventional, disk/field cultivation only	8	9	27	8	34	18	104
Minimum tillage system (strip till, ridge till, etc.)	--	--	1	2	1	5	9
No-till system	4	3	10	4	10	3	34

[a] More than one tillage practice per farm possible, summarized from 2002 interviews.

Table 8 illustrates growers' responses to questions about field scouting and beneficial insects:

- **Very few growers, 6 out of 145, indicated that they practiced insect field scouting in wheat on a regular interval and 45 indicated that they did not scout wheat for insects**. However:
    - 42 indicated that they relied on consultation with a crop advisor when making decisions about insect infestations.
    - 40 indicated that they scout their own wheat for insects whenever they had reason to believe that insects may be a problem.
- **The majority of growers, 133 out of 145, indicated that they have observed beneficial insects in wheat.**
    - When asked to indicate which ones and the typical time of year, 126 out of 145 indicated that they have seen ladybeetles in wheat
    - The most typical time of year to observe beneficials was in the spring.
    - 23 growers mentioned ladybeetle larvae as a beneficial insect they have seen in wheat
    - 65 mentioned seeing (or knowing of) parasitic wasps as a beneficial insect for wheat
    - 54 mentioned lacewings as a known beneficial insect

Computers and the Internet

As noted above, 106 out of 145 growers indicated that they utilized a personal computer for farm records including financial records. We also asked growers about their use of the Internet for obtaining farm related information. As illustrated in Table 9:

- **122 out of 145 growers indicated that they used the Internet.**
- **Growers most commonly sought information on markets and farm machinery**. They also sought current information on weather and research on farm products such as seed varieties, chemicals, and fertilizers.

    • **Forty five out of 144 growers had high speed internet service, but the majority relied on dial-up internet service, 82 out of 144**. Some noted that the slow speed of a dial-up connection limited their willingness or ability to use the Internet regularly for obtaining farm-related information. Seventeen of 144 growers did not have home Internet service.

Table 8. Field scouting and observation of beneficial insects in wheat

	State						All
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	
Field scouting, methods…							
Consultant, all or part acres [a]	--	1	14	3	13	11	42
Self only	7	2	8	2	18	3	40
Self, regular interval mentioned	1	--	--	--	4	1	6
Other, conditional	1	3		3	3	3	13
Not mentioned	5	8	15	4	4	8	45
Total	14	14	37	12	42	26	145
Ever observe beneficial insects in wheat?							
No	1	--	2	--	9	--	12
Yes	13	14	35	12	33	26	133
Total	14	14	37	12	42	26	145
Beneficial insects, most mentioned…							
Ladybeetles	13	14	35	12	29	23	126
Ladybeetle larvae	4	1	9	1	4	4	23
Parasitic wasps	7	--	21	4	19	14	65
Lacewings	3	4	21	4	7	15	54
When have you typically observed beneficial insects?							
Spring	3	8	8	10	23	10	62
Summer	4	1	4	--	1	1	11
Fall	--	--	1	--	2	2	5
Multiple seasons or conditional	--	2	4	1	4	5	16
Not mentioned/unspecified	7	3	20	1	12	8	51
Total	14	14	37	12	42	26	145

[a] Including Extension educator, Co-op agronomist, private crop consultant, or aerial applicator.

Table 9. Use of computers and the Internet for farm information, 2003 cost of production interview

	State						
	Wyoming	Nebraska	Colorado	Kansas	Oklahoma	Texas	All
Use a computer for farm records (including financial)?							
No		3	5	1	18	7	39
Yes		11	32	11	24	19	106
Total		14	37	12	42	26	145
Seek farm related information from the Internet?							
No		5	5	2	4	4	23
Yes		9	32	10	38	22	122
Total		14	37	12	42	26	145
Types of information sought (percentages who used the Internet)							
Commodity markets, cattle markets, financial information	63.	77.8	93.8	100.0	60.5	81.8	77.9
Equipment, machinery, parts	72.	44.4	68.8	40.0	57.9	59.1	59.8
Agricultural research, extension information, trials	90.	66.7	50.0	30.0	63.2	63.6	59.8
Weather	54.	77.8	84.4	90.0	34.2	27.3	55.7
Agricultural news, general news, correspondence	[illegible]	22.2	21.9	40.0	28.9	36.4	27.0
USDA information (FSA, farm programs)		--	6.3	--	5.3	4.5	4.1
Type of Internet access…							
Dial-up service only		7	19	5	22	18	82
High speed Internet		3	15	2	17	6	45
None		4	3	4	3	2	17
Total		14	37	11	42	26	144