

Western Region IPM Grants Program Final Project Report

A. Grant Data

Title: Development and Deployment of an Electronic, Multi-Access Key for Diagnosing Disease, Arthropod and Abiotic Problems of Small Grains

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State(s) involved: Colorado and Montana

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B. Nontechnical Summary

The first step in a successful integrated pest management (IPM) program is rapid and accurate identification of the cause of a plant problem. Delayed diagnosis may allow pests additional time to develop to populations that are not easily controlled by IPM practices. An incorrect diagnosis can result in the application of a pesticide that may have little or no effect in controlling the pest, thus adding to the production costs. For many crops, information about symptoms and other aspects associated with the various causes of crop disorders are discipline-based. For example, publications pertaining to arthropod pests normally do not include information about diseases or abiotic factors that can also adversely affect plant growth. Although problem-specific fact sheets provide valuable information, extension agents, crop advisors, and growers may still find it difficult to diagnose a problem plaguing a crop in production fields. The lack of integration with various sources of information pertaining to causes of plant problems limits the usefulness of fact sheets for diagnostic purposes. Thus, there is a need for

commodity-based diagnostic resources that are integrated, easily accessible, and linked to current IPM recommendations.

Computerized keys for identification of fauna and flora have been in existence since the 1970s; these early keys were dichotomous keys. Constructed using HTML editors, early dichotomous keys were made available to the public via floppy disks, and later via compact disks and the internet. The usefulness of HTML dichotomous keys is limited, due to the fact that these types of keys require considerable amount of time to construct, are difficult to update, often focus on only one or two stages of growth, and their dichotomous nature restricts the choices available to the user who is attempting to make an identification or diagnosis. Matrix keys, also referred to as multi-access or multi-entry keys, provide much more powerful identification tools. Matrix keys allow the user to decide in which order to work through the descriptive characters in the key, depending on the specimen being investigated and the user's ability to distinguish between different character states.

Electronic matrix keys have gained popularity in recent years primarily due to the development of new software. Specialized key building computer programs (e.g. Lucid™ key software products <http://www.lucidcentral.org>) allow developers to easily input descriptive characters and specific entities, along with links to relevant images and various types of media. Matrix keys become more useful when images and sources of additional information are attached or linked to the key. Most the matrix keys that have been developed focus on specific taxonomic groups to aid in the differentiation among the members of that group.

We developed a commodity-based electronic multi-access key that focuses on the pests and disorders associated with wheat in production fields to serve as a diagnostic tool to be used by extension agents, crop advisors, and growers. Problems caused by arthropod pests, disease pathogens, as well as abiotic factors are included in the wheat pest key. We also linked pests in the key to High Plains IPM Guide fact sheets (<http://highplainsipm.org>), as well as to additional sources of information. Images are linked to the descriptive features and the entities included in the key, and descriptive features and the entities are linked to images in the Bugwood Network on-line image collection (<http://www.bugwood.org>). To integrate this key with existing IPM recommendations, this key is housed on the website of the High Plains IPM Guide. The wheat pest key can also be accessed from the Lucid™ website (<http://www.lucidcentral.org>).

C. Introduction

Reason for this project:

Because wheat (*Triticum aestivum*) is an important crop throughout the High Plains region (Colorado, Wyoming, Montana, Western Nebraska, and Western South Dakota), we developed a commodity-based electronic multi-access key that focuses on the pests and disorders associated with wheat in production fields.

The economic importance of wheat to High Plains region states:

Wheat ranks third among field crops in both planted acreage and gross farm receipts nationwide (behind corn and soybeans, respectively). Because the water requirement for wheat is less than that for corn (450-650 mm for wheat versus 500-800 mm for corn [<http://www.fao.org/landandwater/aglw/cropwater/>]), wheat can be a profitable crop for growing in the High Plains region. In 2007, wheat production in the High Plains region varied from state to state, and ranged from 3,445,000 bushels harvested in Wyoming to 149,820,000 bushels harvested in Montana, while production values ranged from \$21,398,000 to \$1,075,754,000, respectively (see the table entitled, State statistics for all wheat planted in 2007 in the appendix of this report for additional state data). In 2007, national acreage planted in wheat increased just 5.60 % over to the acreage planted in wheat in 2005, yet the value of the 2007 harvest was 90.61% greater than that of the 2005 harvest.

The importance of accurately identifying arthropod pests and diseases of wheat, and knowledge of the damage these pests and diseases can cause to wheat:

A successful integrated pest management (IPM) program requires rapid and accurate identification of the cause of a plant problem. Delayed diagnosis may allow pests additional time to develop to populations that are not easily controlled by IPM practices. An incorrect diagnosis can result in the application of a pesticide that may have little or no effect in controlling the pest, thus adding to the production costs. In the case of wheat leaf rust, disease pressure and stage of crop development are significant factors that must be taken into account before preventative fungicides are applied. Applying a fungicide when the disease pressure is determined to be low will increase production costs. Differentiating between Hessian fly damage, greenbug aphid damage, and herbicide carryover damage is essential for a grower as management strategies greatly differ depending on the cause of the problem observed.

The environmental, health, or economic risks associated with non-IPM methods of controlling pests of wheat:

Preventatively spraying for common pests and diseases is not a cost effective way to produce wheat. Knowing what pests and problems to look for , when to look for these, and other factors that may that may influence the onset and development of particular

pests and problems will help to avoid unnecessary use of agri-chemicals. Minimizing the use of pesticides will benefit populations of beneficial organisms and lessen the chances for pest species to build up resistance or tolerance to a particular pesticide.

The primary focus for the development of an interactive diagnostic tool that makes it relevant to stakeholders :

Correct identification of the problem is essential for making sound management decisions.

D. Objectives

Objectives as stated in proposal:

- 1). We will create a general framework for an electronic, multi-entry diagnostic key that contains a matrix of standardized descriptors (characters) that can be used to characterize diseases, arthropods and abiotic plant problems. Field-based characters will include plant growth stage, time of year of pest development, environmental parameters, plant symptoms, and signs of the pest. Laboratory-based characters including morphological macroscopic and microscopic characteristics and biochemical, serological or genomic techniques that can be used to confirm field diagnosis will be added. All characters will be incorporated into commercially available software (Lucid™ Technologies).
- 2). To validate the usefulness of the framework, we will develop ‘as proof of concept’ a diagnostic key specifically for pest and abiotic problems of small grains (wheat and barley). As an aid to diagnosis, we will populate the key with images of specific wheat and barley problems and link to fact sheets hosted on several websites including the Western Regional IPM website, the National Plant Diagnostic Network (NPDN), USDA CPHST, and the High Plains Integrated Pest Management Guide (HPIPM). These fact sheets will provide detailed descriptions of IPM guidelines.
- 3). We will release, at no cost, copies of the small grains pest diagnostic key to extension specialists, diagnosticians, crop advisors, growers and provide training on its use. Traditional training sessions impose a structure on participants that may reduce attendance, retention and adoption of the subject material. Thus we will provide a self paced training video. The video will present actual screens of the Lucid™ small grain key application, an easy to see mouse icon will move across the screen accompanied by a voice describing the task undertaken and the results. Accompanying the video will be short “on your own” lessons allowing the user to migrate from the training video to their own screen and real problem solving.

To satisfy the requirements of the first objective, commercially available software, Lucid™ 3.4 (<http://www.lucidcentral.org>) was used to create the framework of an electronic, multi-entry diagnostic key. This key contains a matrix of descriptors (referred to as features in the key software) that characterize symptoms and/or signs associated with damage caused to wheat by arthropod pests, disease pathogens, and abiotic factors (referred to as entities in the key software). Field-based descriptors include stage of crop development; pattern of the problem in the field; part of the plant is exhibiting symptoms; symptoms and/or signs associated with the problem; weather conditions that preceded the onset of symptoms; as well as descriptions of abnormal growth, damaged tissue, distorted tissue; pathogen signs, and arthropod pests. Laboratory-based descriptors include morphological macroscopic and microscopic characteristics. Information pertaining to biochemical, serological and genomic techniques was placed in the linked fact sheets rather than in the matrix of the key.

To satisfy the second objective, the key contains illustrations and images pertaining to specific wheat problems, as well as links to fact sheets housed on the High Plains IPM Guide (<http://highplainsipm.org>), online glossaries, and relevant websites. The fact sheets provide detailed descriptions of the bacterial, fungal, viral diseases and their causal pathogens, as well as descriptions of arthropod pests that damage wheat. In addition to pest descriptive information, these fact sheets also include IPM guidelines.

To satisfy the third objective, the key has been made available to the public via a link from the small grains page of the High Plains IPM Guide (<http://highplainsipm.org>). The opening page of the key includes instructions on how to use the key. However, the production of the self-paced training video has not occurred due to the departure of Will Lanier prior to the completion of this project.

E. Approach

The key was constructed using Lucid™ Builder 3.4 (<http://www.lucidcentral.org>). After construction of the key, the key was deployed and a link to the deployed key was established on the small grain index page of the High Plains IPM Guide (<http://highplainsipm.org>) so that the key can be viewed and utilized in a player format referred to as Lucid™ Player.

F. Results

The key was released for public use in the summer of 2008 via the High Plains IPM Guide (<http://highplainsipm.org>). To access the key from the High Plains IPM Guide home page, click on “Crops”, then select “Small Grains”; on the small grains index page, click on the “Wheat Pest Key” link at the top of the page. After reading “HOW TO USE THIS KEY”, click on “START KEY!” to open the key. We had initially proposed to develop a training video but instead opted to attach a self-help section directly to the key. The key can also be accessed from the Lucid™ website at <http://www.lucidcentral.org>.

Deployment of the key was delayed until the summer of 2008 (past the wheat production season in most regions) primarily because of the abrupt and unexpected resignation of co-PI Lanier in March 2008. Thus, we missed an opportunity to share and test the key with stakeholders during the 2008 growing season. We will advertise the key and conduct the tests in 2009.

G. Impacts

Safeguarding human health and the environment:

- a. It is hoped that by using the wheat pest key, growers will become more aware of existing IPM practices and implement these into their pest management plan. Based on 2007 USDA data approximately 13,395,000 acres of land were planted in wheat in the High Plains states; IPM practices could be implemented on all 13,395,000 acres.
- b. Use of the wheat pest key by growers could result in fewer applications of pesticide products per season, as well as limit applications of a particular pesticide product to a specific target pest during the growing season, thus reducing harm to nontarget organisms, decreasing the chances for pest species to build up resistance or tolerance to a particular pesticide, and lowering the risk of exposure to pesticide products to farm workers and the nearby general public.
- c. By accessing diagnostic information and additional information via the links in the key, both human and environmental health will benefit in light of the fact that the user can get all the information he or she needs while sitting in their office, kitchen, or family room; thus they can access valuable information without having to leave the farm or home, saving automobile fuel for other activities.

Economic benefits:

- a. Economic benefit that could result for clientele who adopt IPM strategies associated with the wheat pest key include monetary savings that result from not having to purchase and apply a pesticide product or that result from fewer applications of a

pesticide product. The wheat pest key is available FREE OF CHARGE to the public via the High Plains IPM Guide at (<http://highplainsipm.org>), where the key can easily be revised and updated. The key can also be accessed from the Lucid™ website at <http://www.lucidcentral.org>.

b. The public release of the key was delayed until the summer of 2008 and past the time where IPM management decisions would have been made for the growing season. Therefore, It is unknown at this time how many clients are satisfied with the wheat pest key and the IPM strategies linked to the key.

Implementation of IPM:

a. The diagnostic key has been integrated into the High Plains IPM guide. At this point in time, no IPM strategies and systems have been validated through this project.

b. We have delivered a multi-access electronic key for diagnosing wheat pest problems that can be accessed by grower throughout the High Plains region.

c. We have currently trained approximately 100 growers and county agents in two states (Montana and Colorado) on the use of the diagnostic key and its links with High Plains IPM fact sheets. In addition, information concerning the key has been sent to approximately 200 growers, consultants and extension personnel via email messages.

d. User activity on the High Plains IPM Guide website (<http://highplainsipm.org>) is monitored and analyzed using Urchin Software from Google (<http://www.google.com/urchin/index.html>). User activity on the High Plains IPM Guide website for the period of time between January 1 and September 30, 2008 is summarized in the following table. Note that because the the key was officially deployed in mid-summer, it was not available to extension agents, crop advisors, and growers until after the main wheat pest period in the High Plains region.

User activity on the High Plains IPM Guide website (January 1 - September 30, 2008)

| | |
|---|--------------------------|
| Pageviews of High Plains IPM Guide homepage | 20,381 |
| Pageviews of Small Grains Index | 1,057 |
| Pageviews of the opening page of the wheat pest key | 232 |
| The average time spent viewing the wheat pest key | 5 minutes and 45 seconds |

H. Appendices

a. Links to Wheat Pest Key

To access the most recent version of the key from the High Plains IPM Guide home page, click on “Crops”, then select “Small Grains”; on the small grains index page, click on the “Wheat Pest Key” link at the top of the page. After reading “HOW TO USE THIS KEY”, click on “START KEY!” to open the key.

The key can also be accessed from the Lucid™ website at <http://www.lucidcentral.org>.

b. Sources of pertinent wheat production information:

Colorado Wheat (<http://www.coloradowheat.org>)

Montana Wheat and Barley Committee (<http://wbc.agr.mt.gov>)

Nebraska Wheat (<http://www.nebraskawheat.com>)

South Dakota Wheat Commission (<http://www.sdwheat.org>)

South Dakota Wheat Growers (<http://www.sdwg.com>)

Wyoming Wheat Growers Association (<http://www.wyomingwheat.com>)

United States Department of Agriculture’s National Agricultural Statistics Service’s Quick Stats: Agricultural Statistics Data Base (<http://www.nass.usda.gov/QuickStats>)

c. State statistics for all wheat planted in 2007

| State | Acres Planted | Acres Harvested | Average Bushels per Acre | Total Harvested (Bushels) | Value of Production (\$) | Percent USA Value of Production |
|--------------|---------------|-----------------|--------------------------|---------------------------|--------------------------|---------------------------------|
| Colorado | 2,520,000 | 2,369,000 | 40.3 | 95,520,000 | 607,844,000 | 4.45 |
| Montana | 5,170,000 | 5,065,000 | 29.6 | 149,820,000 | 1,075,754,000 | 7.87 |
| Nebraska | 2,050,000 | 1,960,000 | 43.0 | 84,280,000 | 522,536,000 | 3.82 |
| South Dakota | 3,509,000 | 3,328,000 | 44.3 | 147,516,000 | 960,515,000 | 7.03 |
| Wyoming | 146,000 | 130,000 | 26.5 | 3,445,000 | 21,398,000 | 0.16 |
| USA | 60,433,000 | 51,011,000 | 40.5 | 2,066,722,000 | 13,669,482,000 | ***** |

Source: United States Department of Agriculture’s National Agricultural Statistics Service’s Quick Stats: Agricultural Statistics Data Base (<http://www.nass.usda.gov/QuickStats>)