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Application Note

CPIDS: a plant parameter selection program for erosion prediction modeling[1]

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Abstract

Newly developed erosion prediction models require detailed input parameters including those describing cropping systems. Each model exhibits a different level of complexity for crop growth modeling, and many plant parameters for these models are difficult to obtain. Furthermore, numerous parameters require interpretation from other measurable plant characteristics. We developed a database containing measurable plant characteristics to supply users of these new erosion prediction technologies with the necessary parameters. The new database supports the Revised Universal Soil Loss Equation (RUSLE) and the Water Erosion Prediction Project (WEPP) erosion prediction models. The Crop Parameter Intelligent Database System (CPIDS) was developed to assist crop database builders and users of RUSLE and WEPP in interpretation of plant characteristics and selection of plant parameters. CPIDS is a Microsoft® Windows™-based program, currently running on a personal

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computer (PC) under Windows 3.1™, Windows 95™ and Windows NT 4.0™.

Keywords: Computer software; Database; Erosion models; Crop characteristics; Soil loss

1. Introduction

Users of new technology erosion prediction tools, such as the Revised Universal Soil Loss Equation (RUSLE; Renard et al., 1991; Yoder and Lown, 1995) and the Water Erosion Prediction Project (WEPP; Flanagan et al., 1995) models, can estimate erosion losses for row and small grain crops, along with 'non-traditional' plants such as vegetables and other cash crops. These models are more parameter intensive than previous erosion prediction technologies, and contain plant input parameters for less traditional crops describing attributes or characteristics not easily measured or quantified. Very little plant growth and residue information for vegetable and cash crops is readily available, however, users such as the USDA-Natural Resources Conservation Service (NRCS; formerly the Soil Conservation Service, SCS), Cooperative Extension Service, Universities, and USDA-Agricultural Research Service (ARS) must have model input parameters that closely resemble plant conditions in the field. Extensive crop data collection was required to make the erosion prediction models useful for field situations. The Crop Parameter Intelligent Database System (CPIDS) database and interpretive interface were constructed to provide a graphical display of and easy access to crop parameters and to expand the number and types of crops that may be used with erosion prediction models such as WEPP and RUSLE. The USDA-NRCS has dedicated a National Plant Data Collection Center in Baton Rouge, LA, for maintaining the current database and broadening its scope to global crops.

The CPIDS database is not limited to use by only WEPP and RUSLE; it also should be helpful in crop component parameterization for the Revised Wind Erosion Equation (RWEQ; Fryrear et al., 1994) and the Wind Erosion Prediction System (WEPS; Hagan, 1991). These wind erosion prediction models contain crop growth components that require similar levels of plant-specific information. The RWEQ model contains a management file where plant characteristics and data describing the interaction of the plant and field operations are supplied. Both WEPS and WEPP contain a modified version of the Environmental Policy Integrated Climate (EPIC, formerly Erosion Productivity Impact Calculator) model (Williams, 1995) plant growth component (Williams et al., 1989). The subroutines within the plant growth component simulate temporal changes in plant and residue variables, such as canopy cover and height, and residue cover that influence the runoff and erosion process. The RUSLE model has a database with individual crop data sets containing parameters describing root and canopy growth characteristics,

as well as residue mass and decomposition characteristics for specific plants or plant communities.

Many crop growth models have been developed that predict plant production (e.g. CERES-Maize (Jones and Kiniry, 1986; Kiniry and Knievel, 1995); SHOOTGRO (McMaster et al., 1992); and BEANGRO, SOYGRO and PNUTGRO (Hoogenboom et al., 1992, 1994)). However, the scale and level of detail of these models is much more complex than the crop growth components in the wind and water erosion prediction models. The CPIDS database contains crop data from a much broader scope, whereas the application of highly mechanistic crop models is limited to a minimal number of plants. Therefore, the CPIDS crop database provides more appropriate data for use in the erosion prediction models than is possible with the crop growth models. The reader also should be cognizant that accurate crop growth prediction improves erosion prediction, however, the ultimate goal of WEPP, RUSLE, WEPS and RWEQ is to simulate erosion and not plant production.

The remainder of this paper describes CPIDS database and interface development, presents information on how CPIDS may be applied to parameterize plant data sets for use in erosion and water quality prediction models, and discusses NRCS use of CPIDS.

2. CPIDS database and interface

2.1. Development

The CPIDS crop database is written in DBASE IV™ and contains approximately 2500 records. It represents a combination of measured field data and expert advice including information from unpublished field studies, published literature and surveys from experienced agronomists, horticulturists and producers. Knowledge available in the literature was used whenever applicable. Information describing management practices used in the studies, stresses (e.g. temperature, water and nutrient), fertility levels, varieties, etc. also were collected along with plant specific parameters. Descriptive information is available for each plant record to help the user best interpret the usefulness of the data. Table 1 lists plant characteristics that were collected for the CPIDS database. Nearly all plant parameters needed by the erosion prediction models can be calculated from the database.

Four USDA-NRCS sponsored studies, occurring at Alabama A&M University, North Carolina A&T State University, University of Hawaii at Manoa, and Alcorn State University, are providing valuable information for the database. They were designed by Natural Resources Conservation Service agronomists, Agricultural Research Service scientists, and the university staffs to collect data for use by erosion prediction modelers to help describe the effects of plant and residue cover on erosion. The crops being grown for these studies are meaningful to the local agriculture of the area impacted by each university. The Alabama A&M study at Normal, AL, collected cotton plant growth data under different management

practices in 1993. The North Carolina A&T study at Greensboro, NC, was initiated in 1992 for collection of plant growth and residue decomposition data on both vegetable and field crops. The University of Hawaii at Manoa study was initiated in 1991 for collection of sugarcane, pineapple, and taro growth and biomass data. The Alcorn State study in Lorman, MS, was initiated in 1989 and is collecting plant growth and residue decomposition data on vegetable and fruit crops.

Table 1
Plant database fields and descriptions

Plant parameter name	Parameter description
Crop_Name	Name of plant
Category	CPIDS classification category
Use	Plant use: fresh market, processing, forage
Location	Location where the record data are pertinent
LRR	Major land resource region location is within
Hard_Zone	Hardiness zone
Plant_Form	Method by which the crop is planted (seed, transplant, seed piece, etc.)
Cultivate	Cultivation type used
BTEMP	Base temperature of the plant
OTEMP	Optimum temperature for plant growth
TMPMAX	Maximum temperature for plant growth
TMPMIN	Minimum temperature for plant growth
JDPLT	Julian planting date
JDHARV	Julian harvest date
CRIT	Growing degree days from planting to emergence
GDDMAX	Growing degree days from planting to maturity (or harvest)
FDROP	Days from planting to start of leaf drop
DLAI	Fraction of growing season until leaf area index declines
PLTSP	In-row plant spacing
RW	Row spacing
HMAX	Maximum height of plant
DIAM	Stem diameter of base of plant
DFP, VDM, CHGT, CCOV	Days from planting, associated vegetative dry matter, canopy height and canopy cover
XMXLAI	Maximum leaf area index
DECFCT	Canopy cover after senescence
RDMAX	Maximum rooting depth
RSR	Ratio of root biomass to above-ground biomass
RTMMAX	Maximum root biomass for a perennial
RTDAY, RTM	Days from planting and associated root biomass
EYLD	Economic yield
ABVBM	Above-ground biomass at harvest
Y4	Mass of yield per volume of yield
CN	Carbon-Nitrogen ratio at harvest
MFOCOD	Residue classification: fragile, non-fragile

2.2. Information access and display

Erosion prediction models are often developed for use with traditional row crops in mind. However, federal agencies also have a responsibility to deliver models that work for other types of agricultural systems. The CPIDS database was constructed to provide information for alternative crops including: (1) vegetables and fruits; (2) forage crops; (3) non-traditional row crops; and (4) vineyard crops. To provide appropriate database access and plant parameter display, a Microsoft® Windows™-based graphical user interface (GUI) was developed. The GUI not only links the user to information contained within the database, but provides capabilities for database search and acquisition, crop data interpretation, assistance in parameterizing the crop components of the erosion prediction models, and heuristic (rule of thumb) information in the cases when the data are inadequate for complete parameterization of a particular crop. The GUI with these enhancements, coupled with the comprehensive plant parameter database, encompasses the CPIDS software program for plant parameter selection.

3. Application of CPIDS

3.1. Running CPIDS

CPIDS has added features for accessing the crop database beyond the typical searching allowed in database systems. It is targeted towards field specialists, scientists, researchers or students who are interested in simulating alternative crop management systems with new erosion prediction technologies. CPIDS was developed using Microsoft® Visual Basic™, and currently runs on a personal computer (PC) under Windows 3.1™, Windows 95™ and Windows NT 4.0™. Other basic requirements include a PC using an 80486 or higher microprocessor, 4 Mbytes of memory resources while under Microsoft® Windows™, and approximately 13 Mbytes of hard disk space.

The user is first presented with a CPIDS introductory screen and then enters the main menu screen as shown in Fig. 1. Interactive prompts for guiding the novice user through CPIDS are available. Once the user becomes familiar with CPIDS, these messages may be disabled using the check box located in the lower left-hand portion of the main menu screen. To start a CPIDS session, the user typically selects a crop and geographic location to build a search. Currently, vegetable and non-vegetable crop categories are available. As the CPIDS database expands, the crop categories will become more specific. The user highlights a crop of interest from a list box containing vegetable crops available for parameterization and chooses the 'Select' button. A geographic location should be selected next in order to display information on a site-specific crop that is most applicable to a particular user. The geographic location preferences listed under the main menu item, 'Build' (Fig. 1), include: (1) land resource region; (2) hardiness zone; (3) state; or (4) none. The land resource regions are adapted from major USDA land resource areas of

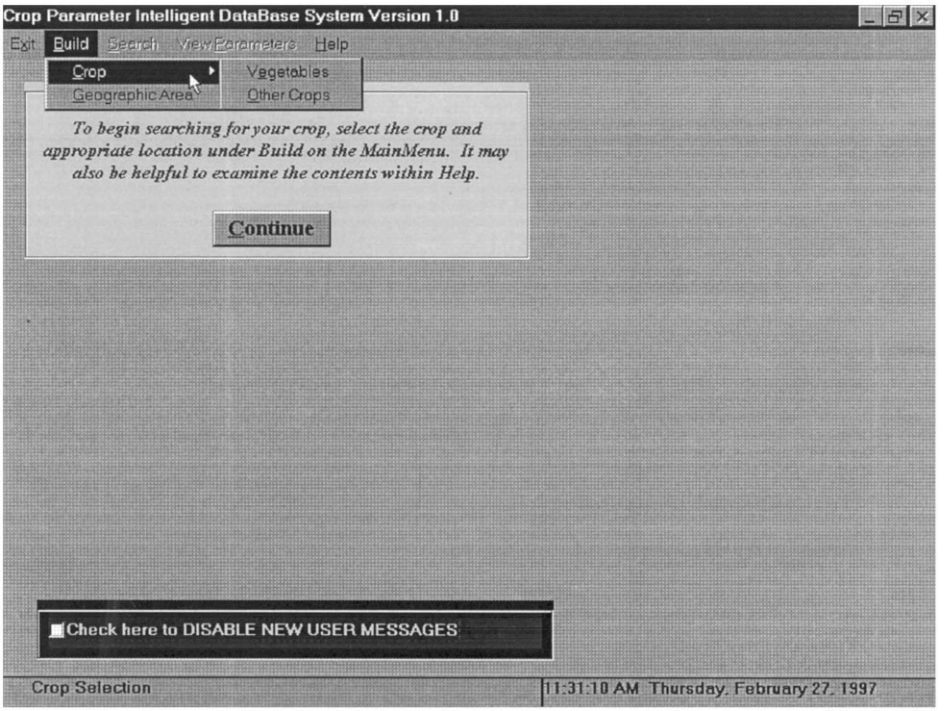

Fig. 1. CPIDS main menu screen.

the United States (USDA-SCS, 1981). The hardiness zone is based on information from the USDA (USDA-ARS, 1972). The user is able to view all information contained in the database for a particular crop or focus on a specific geographic region.

Once the crop and geographic location have been selected, a search for the appropriate database is made. All database entries matching the search conditions are presented to the user. If no matching records are located, revisions may be made to the search conditions and the database rechecked, or the user may exit the system. Each matching record contains a description of its contents as displayed in Fig. 2. These descriptions help the user decide if the information contained within that particular record is useful. The user may decide to tag the record description using the 'Keep Record' or 'Keep All Records' buttons. The user can then proceed using the 'Next Record' button. When the user has finished viewing all record descriptions matching the search conditions, the 'Quit Viewing' button may be selected. Any or all records that were tagged will be saved for detailed viewing. If none of the matching record descriptions contained useful information, the user may change the search conditions using the 'Revise Search' button to determine if other records for similar crops or regions are more relevant. Descriptions of the three search revision options available to the user are shown in Fig. 3. Once the user has finished viewing the record descriptions, CPIDS permits the user to view

detailed information for those records marked for saving. This is accomplished by selecting either the RUSLE or WEPP model under 'View Parameters' from the main menu to display appropriate, model-specific types of cropping information. Plant parameter categories available when a user views cropping information specific to either the RUSLE or WEPP model are listed in Table 2.

The user may browse through the saved records and view information for a specific category. All categories for each record may be viewed. Because each record contains crop information from a single source, not all categories will contain information. Unavailable information is indicated by a 'N/I' (No Information). The user may move through the categories for each saved record and print or save that particular information to a file for later reference. A 'View Parameters' screen containing WEPP parameter information for broccoli is presented in Fig. 4. A scrolling list box, found in the lower left hand corner of this screen, lists the classes of information needed for the WEPP model.

Assistance is available when viewing parameter information for both WEPP and RUSLE. If a WEPP user selects 'Assistance' (Fig. 4), two choices are presented. Helpful information and heuristics have been collected for use in parameterization of vegetable crops. The user may view these suggestions or browse through descriptive information (Fig. 5) that aids in making parameter value adjustments that better reflect a user-specific situation. The 'Assistance' option for RUSLE

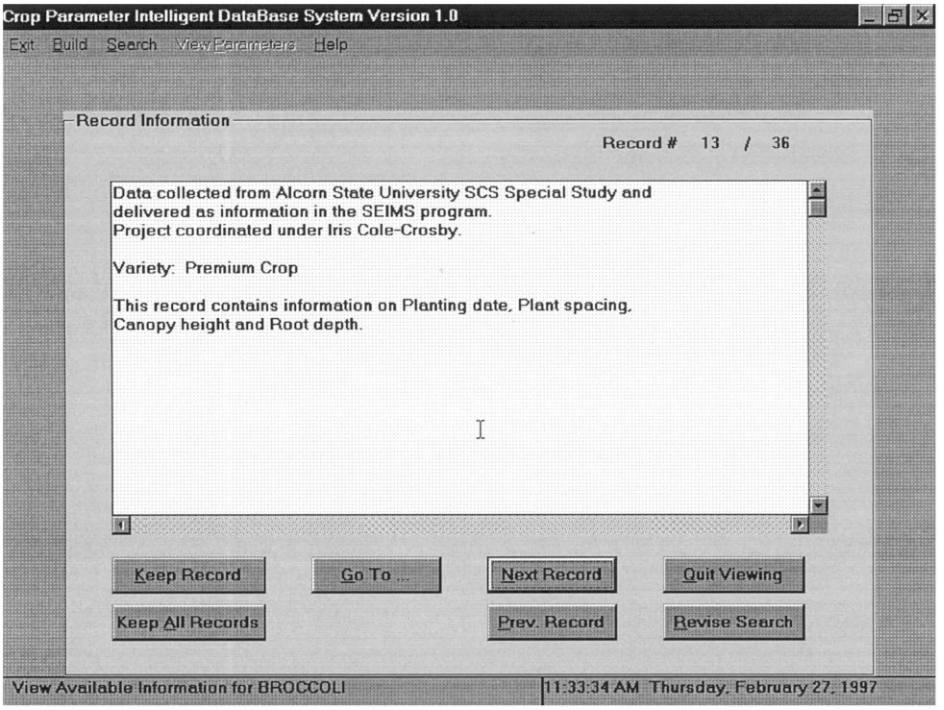

Fig. 2. Display of record matching search conditions.

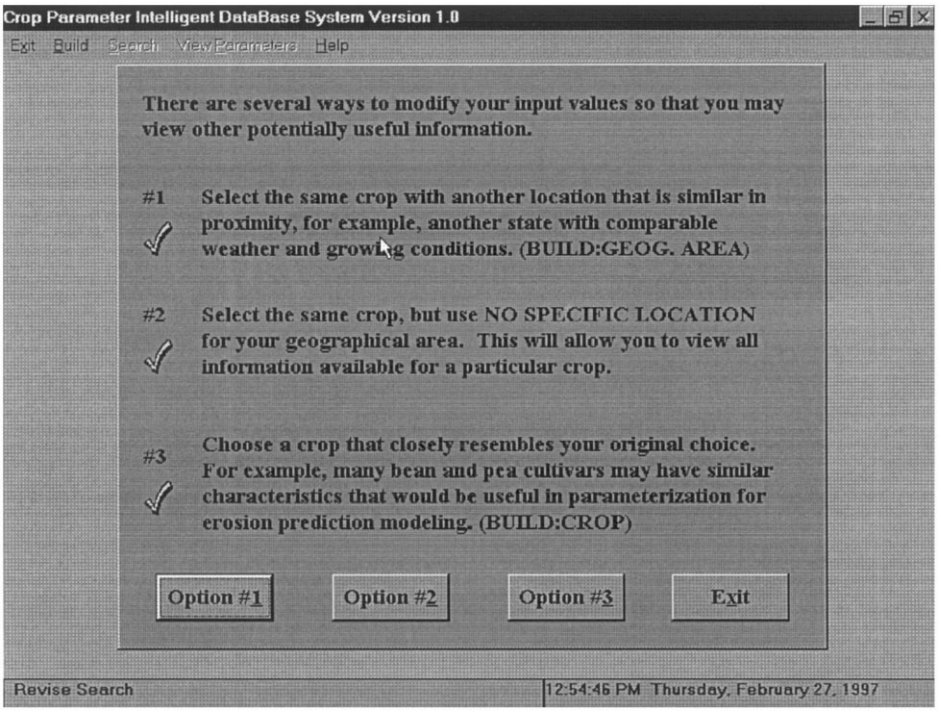

Fig. 3. Search revision options available in CPIDS.

allows the user to view all saved record information for the current crop parameter category (e.g. residue) in one screen, as shown in Fig. 6. This may be displayed in graphical or tabular format, as appropriate, and saved to a file. This layout of information will be useful for later development of crop data sets for RUSLE.

Table 2
CPIDS plant parameter categories for WEPP and RUSLE

WEPP	RUSLE
Canopy: leaf area index	Planting
Harvest	Growth
Heat unit	Rooting
Miscellaneous growth	Harvest
Planting	Residue
Residue	
Rooting	
Senescence	
Temperature	

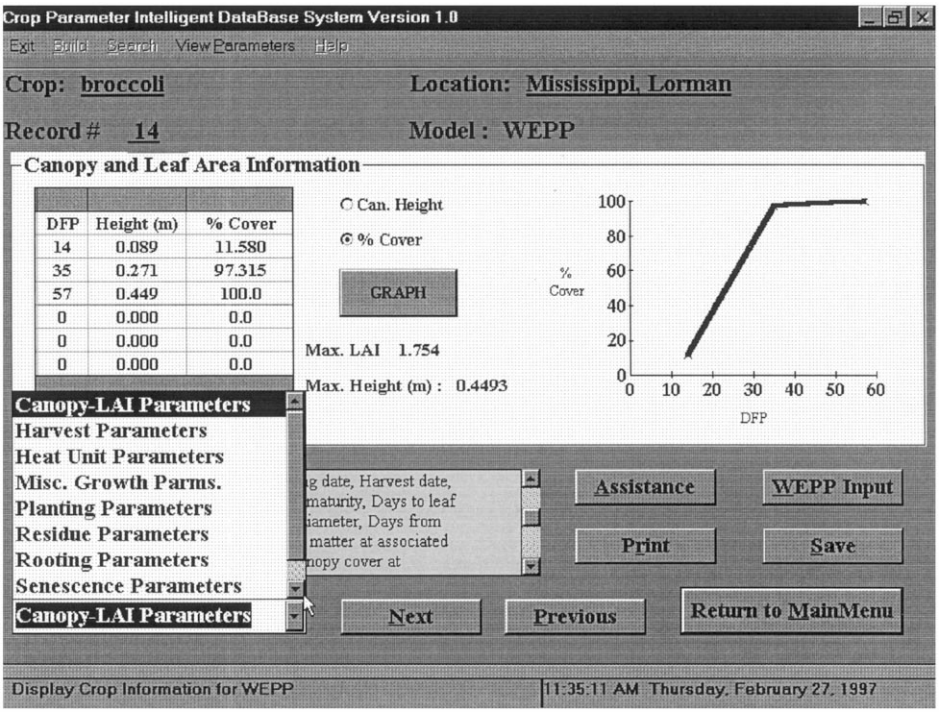

Fig. 4. Display of record information in WEPP output format.

The WEPP user also may create a plant parameter file for use in the WEPP Shell Interface Program (Flanagan and Livingston, 1995). By selecting the 'WEPP Input' button (Fig. 4), values for the current record will be displayed as shown in Fig. 7. The user has the capability to replace and save any desired values. Prior to the termination of the CPIDS session, the user will be prompted for additional information to be included in the comments section of the plant parameters file. Once all WEPP input variables are assigned in CPIDS, a file can be saved for use in creating future WEPP cropping scenarios directly with the WEPP shell file builder. The WEPP shell file builder allows for the addition of as many CPIDS cropping files as desired by the user.

On-line help is available to the CPIDS user and can be accessed by selecting 'Help' in the main menu screen. Fig. 8 shows specific information contained in the help section which serves as on-line user documentation explaining how CPIDS may be used. CPIDS uses Windows™ functionality so help information may be printed or browsed using hypertext/hyperlinks. A glossary help section also was created to assist users with CPIDS terminology. The glossary includes parameter definitions and units of measurement for the cropping component of each erosion prediction model.

3.2. Testing CPIDS

The CPIDS GUI and crop database system were verified in-house at the USDA-ARS National Soil Erosion Research Laboratory, West Lafayette, IN. Once preliminary testing was completed, the system was distributed to selected USDA-NRCS agronomists and conservationists at regional technical centers for beta evaluation. Beta test copies of CPIDS also were distributed to ARS personnel at their request. Following beta testing, suggestions for improving the system and making it easier for parameterizing crops for WEPP and RUSLE were incorporated.

3.3. Natural resources conservation service use of CPIDS

The USDA-NRCS is the primary target group for using CPIDS since that agency will be a primary user of the new erosion prediction models. Other CPIDS users include those developing the management files for non-traditional crops used in WEPP model validation studies or those using WEPP and RUSLE as research and teaching tools. CPIDS users in NRCS generally are agronomists on a state, regional or national level. They are responsible for assisting conservationists in field offices with application of RUSLE as a tool in conservation planning, resource inventories

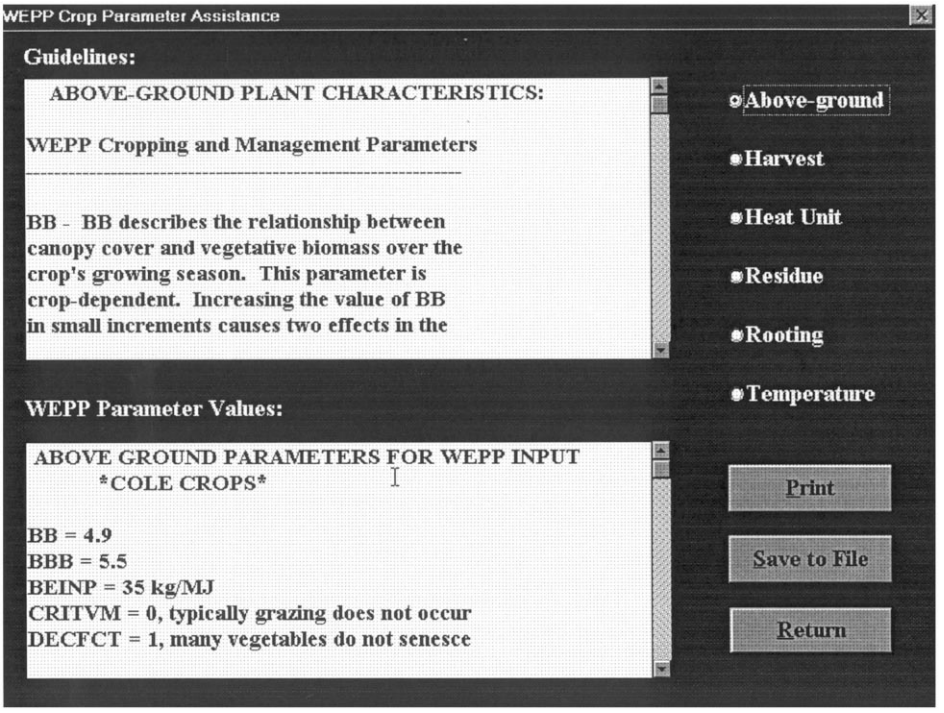

Fig. 5. Assistance information in CPIDS for WEPP users.

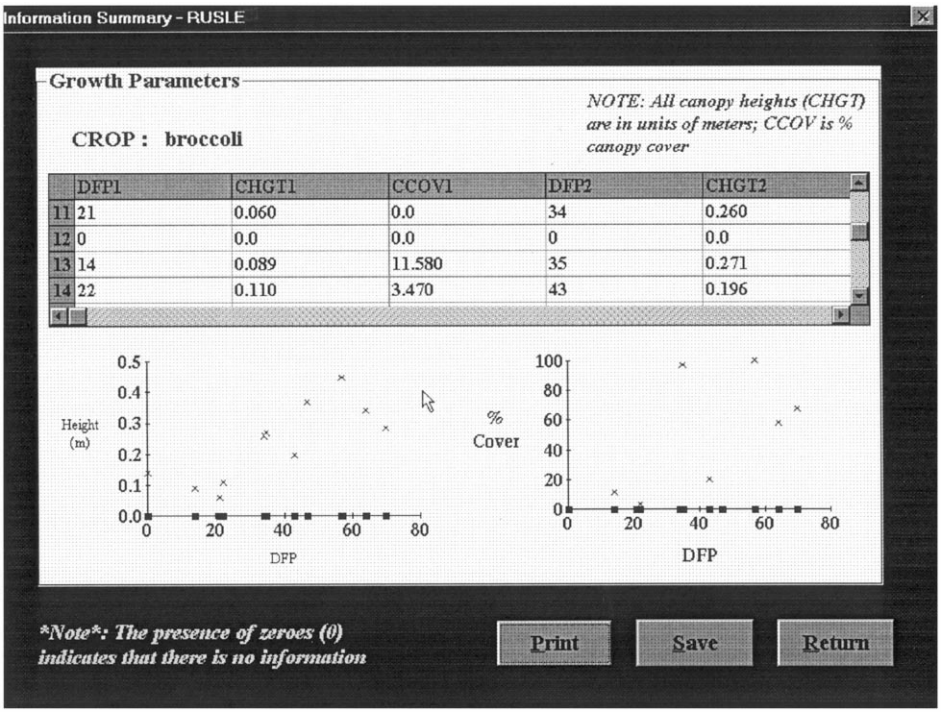

Fig. 6. Assistance information in CPIDS for RUSLE users.

and other activities. The staff at the NRCS National Technical Centers and State Offices currently have responsibility for developing, maintaining and expanding the RUSLE crop database, and are current users of CPIDS.

For example, a NRCS field conservationist may wish to estimate soil loss on a hillslope planted to soybeans, drilled in 15 inch rows, yielding 35 bushels per acre, and grown in Southern Indiana. Using CPIDS, the state agronomist reviews all soybean data that meet at least one of these criteria. While it is unlikely that CPIDS would represent all these conditions, the agronomist uses professional judgment to select the most appropriate values from the information available in CPIDS. These parameters are the basis for developing the specific plant data sets in the erosion prediction model. Using RUSLE or another erosion prediction tool, the conservationist in the field office can then estimate erosion using these specific plant conditions.

4. Discussion

The CPIDS was developed to assist users of erosion prediction models such as WEPP and RUSLE with parameterizing crops for management input information. CPIDS is particularly useful for non-traditional cropping systems and also can

provide assistance with adjustment of cropping parameters that reflect geographical differences. Other erosion and water quality models use crop growth components similar to that found in WEPP. Examples include: (1) Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model (Leonard et al., 1987); (2) Agricultural Non-Point Source Pollution model (AGNPS) model (Young et al., 1987); (3) Environmental Policy Integrated Climate (EPIC) model (Williams, 1995); (4) Wind Erosion Prediction System (WEPS) model (Hagan, 1991); and (5) Revised Wind Erosion Equation (RWEQ) model (Fryrear et al., 1994). Users of these models may find CPIDS helpful for applications with plants other than traditional row crops.

The data collection effort for crop parameterization is continuing at the USDA-NRCS National Plant Data Collection Center in Baton Rouge, LA. Future work on CPIDS will include expansion of the database and the delineation of the crops categories into more specific and separate databases, including forage crops, orchard crops, vegetables, small grains or traditional row crops. The system scope expands since data are continually being added to the database, and users can easily access the expanding database for new and existing crops. Additional data collection must continue to allow global use of the database and application to WEPP and RUSLE.

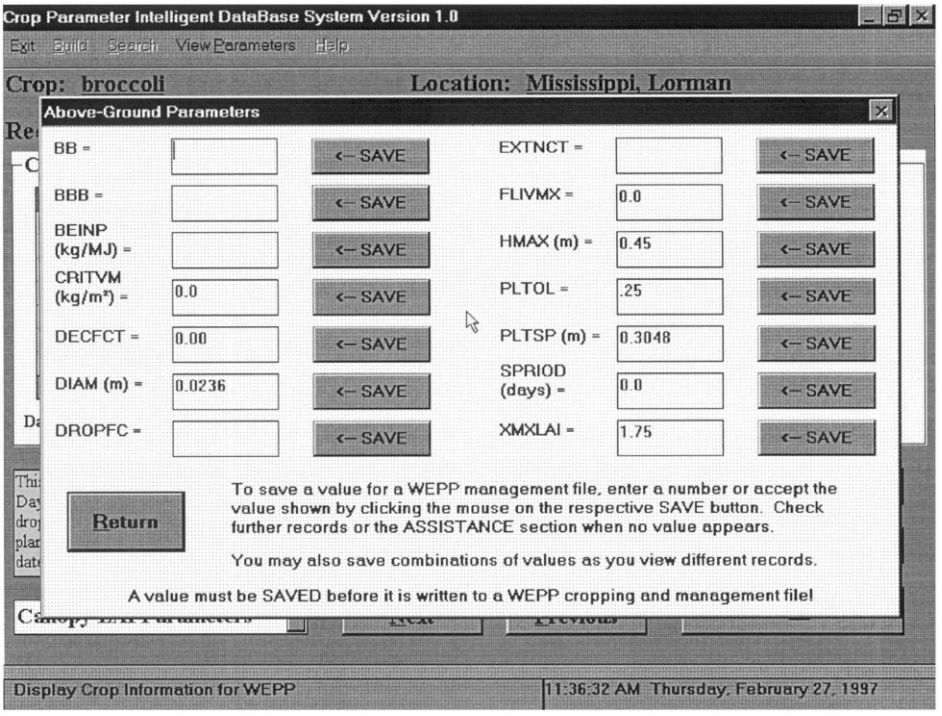

Fig. 7. Saving crop parameter values for future use with the WEPP shell file builder.

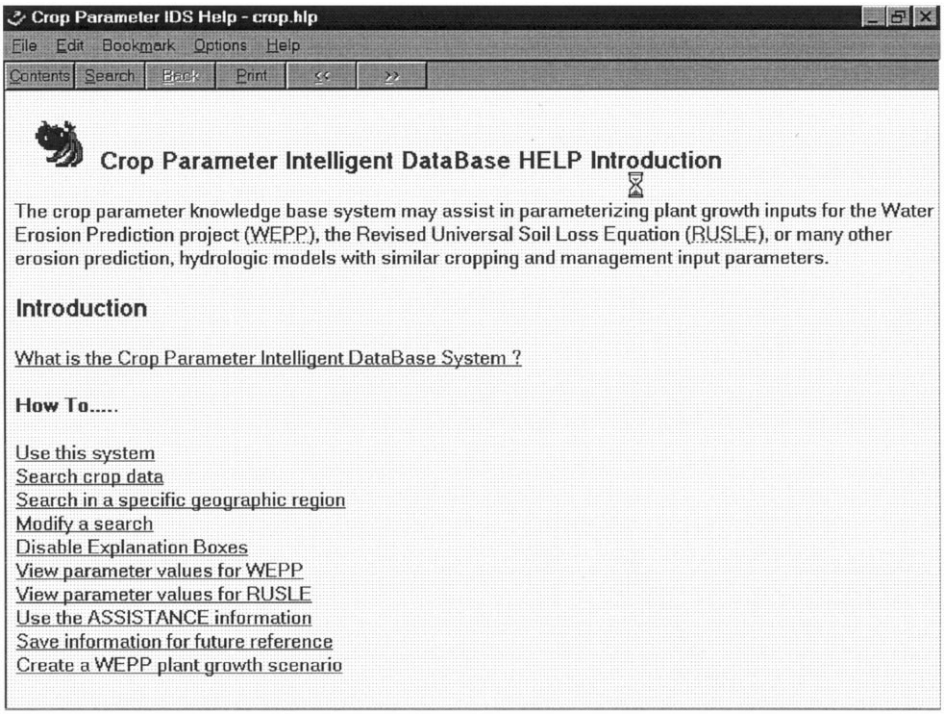

Fig. 8. CPIDS on-line help information screen.

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