Software

SELECT!: Crop Variety Selection Software for Microcomputers

Joseph G. Lauer

Research Question

The selection of a good variety is one of the most important management decisions producers make for their farms. Selecting the correct crop variety can often mean the difference between breaking even and making a profit. Plant breeders test thousands of new experimental varieties for several years at many locations over a range of plant populations and other management practices. The results of variety evaluations are popular among producers. But, the amount of information available can be daunting to producers and make their variety selection decision difficult.

The computer software program, SELECT!, is a decision support system for selecting crop varieties. SELECT! links variety traits and trial characteristics with variety performance tested in state agricultural experiment station trials. Its objectives are to assist producers, county agents, and other crop consultants in evaluating crop variety adaptation and performance using data from evaluation trials conducted by the agricultural experiment station, and to provide agricultural producers with production information regarding crops and varieties. Varieties selected by producers should be planted and evaluated on a *trial* basis using their farm management practices.

Software Description

SELECT! was written using Clipper and C programming languages. SELECT! requires an IBM PC, XT or AT, or a 100% IBM compatible computer. The computer must include the following features: (i) PC-DOS or MS-DOS Version 3.1 or greater for single-user applications or network applications, (ii) 384K, or more, of Random Access Memory (RAM), (iii) one diskette and one hard disk drive, (iv) ANSI terminal support, (v) a printer, and (vi) a math co-processor chip. In general, the faster the microprocessor of the computer, the better SELECT! will perform. SELECT! has virtual memory capabilities that will automatically use RAM, expanded memory, and, if necessary, hard disk space. The virtual memory manager provides up to 64 megabytes of accessible memory space, effectively removing any practical limitations on the memory requirements of SELECT!

Applied Question

Is the SELECT! program useful for selecting crop varieties?

SELECT! is being used in the field by Wyoming county agents. Extension specialists tailor crop data bases for Wyoming. Early reviews of SELECT! beta test versions by county agents, crop consultants, and producers have been positive. Work continues on developing databases and tailoring crop production recommendations for Wyoming conditions.

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SELECT!: Crop Variety Selection Software for Microcomputers

Joseph G. Lauer*

The selection of a good crop variety is an important management decision producers make for their farm. It can often mean the difference between breaking even and making a profit. Agronomists often struggle with summarizing and accurately describing variety performance due to the large amount of data and the many methods for describing performance. The software program, SELECT! version 1.0, is a microcomputer based decision support system for selecting crop varieties. SELECT! links variety traits and trial characteristics with actual variety performance. Its objectives are to assist producers, county agents, and other crop consultants in evaluating crop variety adaptation and performance using data from evaluation trials conducted by the agricultural experiment station, and to provide producers with production information regarding crops and varieties. Varieties selected by producers should be planted and evaluated on a *trial* basis using their farm management practices.

CROP VARIETY PERFORMANCE information is popular among growers. But often, the volume of information available from both public institutions and private companies makes selection of a high performing variety difficult and confusing. Yet, selecting a good variety is one of the most important management decisions producers must make for their farms, and it can often mean the difference between breaking even and making a profit.

Plant breeders test thousands of new varieties and experimental lines for several years at many locations over a range of management practices. Performance trials determine if newer varieties or experimental lines have yielding ability superior to current varieties. Pest resistance and other important agronomic characteristics are also reported. Results are distributed through many formats including brochures, handbooks, field days, and commodity meetings.

Agronomists often struggle with summarizing and accurately describing variety performance. Questions often asked by agronomists when preparing trial results include:

- What environments should be summarized for a variety?
- Should data be summarized by location, soil type, precipitation zones, cropping system, rotation, latitude, altitude, or management level?
- Should varieties be compared against check varieties? If so, which ones?

The amount of available data and the many methods to describe performance make the process of data summarization difficult. This process is often the major limitation associated with producers making a good decision.

Computers are a useful tool for sorting and summarizing data and information. Software development should emphasize and teach skills which foster lifelong learning strategies. Extension educators should strive to develop with their clients the analytical skills for handling massive amounts of information, and the capacity for self-direction in variety selection decisions. Compared with more traditional information transfer mechanisms, such as printed materials and meetings, computer based information systems offer many advantages including faster turnaround between field trial results and the software user, electronic downlinking from a central source, more methods for summarizing and working with results, many check variety comparisons, and continuous long-term accumulation of the crop data sets. Increasingly, computers are becoming more widely used as on-farm decision support systems (Iddings and Apps, 1990).

Computer software for variety selection purposes has been developed for soybeans [*Glycine max* (L.) Merr.], alfalfa (*Medicago sativa* L.), and small grains (Helsel and Burns, 1984; Hannaway et al., 1984; Boyer and Palmer, 1984; Carlson and Hannaway, 1984; Carrascal and Pau, 1992; Shroyer et al., 1986; Wisiol and Pepper, 1986; Thomison and Short, 1988; Kephart et al., 1989; Ashlock et al., 1991; Thien and Schapaugh, 1992). In addition, USDA has developed the Germplasm Resources Information Network located at Beltsville, MD (Anonymous, 1992). These programs either filter varieties from a larger, more comprehensive list to a shorter list based on traits, or are "expert system" based.

SELECT!, is a microcomputer based decision support system for choosing crop varieties and was developed for Wyoming producers. SELECT! allows sorting and selecting of varieties based on traits and then summarizes their performance using data derived from agricultural experiment station trials. SELECT! was developed to assist producers, county agents, and other crop consultants in evaluating crop variety adaptation and performance, and to provide producers with production information regarding crops and varieties. Varieties selected by producers should be planted and evaluated on a *trial* basis using their farm management practices.

PROGRAM DESCRIPTION AND EXECUTION

Design Considerations

Methodologies for the design of computer-based decision support systems have been described by Farrell et al.

(1992). Spreadsheets and databases are used to retrieve specific information. Deterministic simulation models use specific inputs to generate predictions. Stochastic models use inputs and incorporate uncertainty and fuzzy logic to generate predictions. Rule-based expert systems use case studies and generalizations to suggest optimal management actions. Future decision support systems will evolve to single models incorporating elements from databases, deterministic simulation models, stochastic models, and rule-based system methodologies (Farrell et al., 1992).

SELECT! version 1.0 uses databases as the primary methodology for selecting crop varieties. SELECT! databases describe variety traits and trial environment and management conditions. The objective of crop variety trials is to determine the most likely performance ranking of varieties for a given set of environmental conditions and management factors. The genotype interacting with the environment in which it is grown ultimately determines its performance (Fig. 1). Yield may not be the most important factor. Other factors such as quality or disease resistance must be taken into consideration when making crop variety selection decisions. In SELECT!, crop variety performance can be compared with any other variety in the database, and thus, predictive capabilities regarding relative performance of varieties can be assessed for various environmental and management conditions.

The SELECT! software uses four files with each crop. One file is an ASCII text file that contains recommendations for production practices for each crop. The three other files are relational databases which are closely associated parent-child files (Fig. 1). Relational databases describe a system composed of separate files that comprise a single database. The use of a relational database makes the information component of the system explicit and allows it to be normalized (having little duplication, redundancies or ambiguities of data). Relational databases allow information to be readily accessible and easily modified or updated. This method of storing data makes efficient use of disk space since information associated with many records is stored only once and normalized. Most variety descriptions and performance trials are referenced.

The relational databases are organized around varieties, environments, and performance (Fig. 1). The two parent files are the variety trait and the trial characteristic files. In the crop variety trait file, each variety has been given a variety identification (VAR_ID) number. In the trial characteristic file, each trial has been given a trial identification (TRI_ID) number. The third file contains actual performance results. This child file contains both variety and trial identification numbers.
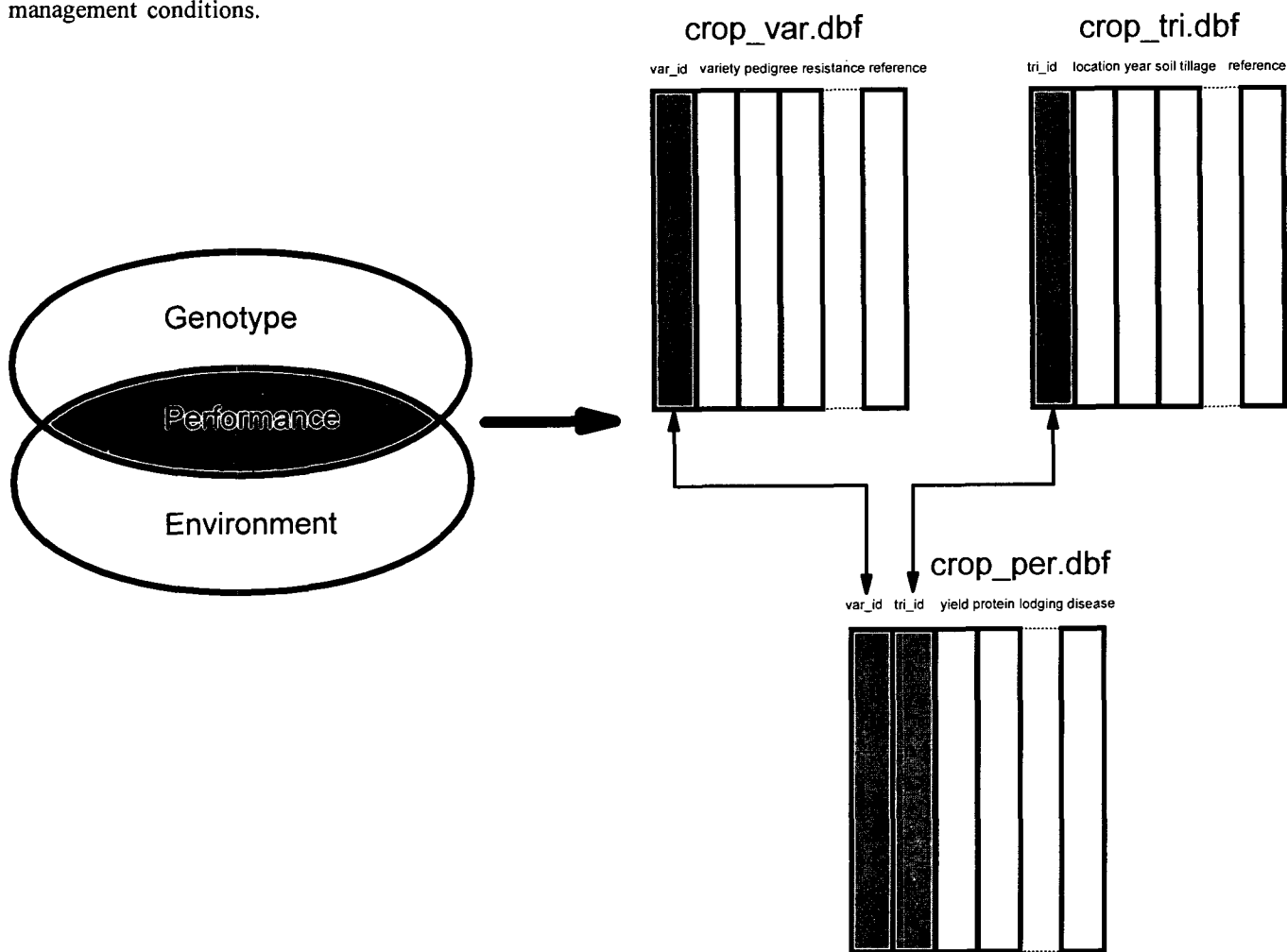

Fig. 1. Stylized diagram showing the relationship between genotype traits, environmental factors, and resulting performance, and the approach SELECT! uses to simulate this interaction using parent-child relational data sets.

Table 1. List of crops and number of varieties, trials, and variety (V) × location (L) × years (Y) in Crop Variety SELECT! (as of 1 Oct. 1993).

Crop	Scientific name	SELECT! abbreviation	Varieties	Trials	V × L × Y
		Grains			
Amaranth	*Ameranthus cruentus* L.	AMAR	7	2	0
Barley ·	*Hordeum vulgare* L.	BARL	424	322	4 661
Corn	*Zea mays* L.	CORN	1 285	300	6 490
Millet	Many species	MILL	15	0	0
Oat	*Avena sativa* L.	OAT	226	298	3 334
Rye	*Secale cereale* L.	RYE	9	2	0
Sorghum	*Sorghum bicolor* L. Moench	SORG	53	27	208
Triticale	X *Triticosecale* Wittmark	TRIT	18	4	48
Wheat	*Triticum vulgare* Vill. *aestivum* L.	WHEA	502	459	6 334
		Grass forages			
Bromegrass	*Bromus* sp.	BROM	26	69	610
Fescue	*Festuca arundinacea* Schreb.	FESC	22	16	142
Misc. grasses	--	MISG	45	46	286
Orchardgrass	*Dactylis glomerata* L.	ORCH	47	44	456
Timothy	*Phleum pratense* L.	TIMO	15	13	83
Wheatgrass	Many species	WH_G	100	110	1 245
Wildrye	*Elymus* sp.	WILD	33	77	360
		Legume forages			
Alfalfa	*Medicago sativa* L.	ALFA	542	283	5 589
Birdsfoot trefoil	*Lotus corniculatus* L.	BIRD	14	1	0
Clovers	*Trifolium* sp.	CLOV	20	1	0
Misc. legumes	--	MISL	14	2	0
Sainfoin	*Onobrychis viciifolia* Scop.	SAIN	18	13	152
		Miscellaneous			
Kenaf	*Hibiscus cannabinua* L.	KENA	4	2	0
		Oilseeds			
Crambe	*Crambe abyssinica* Hochst	CRAM	19	7	50
Mustard	*Brassica* sp.	MUST	17	2	27
Rape	*Brassica* sp.	RAPE	148	19	251
Safflower	*Carthamus tinctoris* L.	SAFF	31	35	228
Soybean	*Glycine max* (L.) Mer.	SOYB	87	15	193
Sunflower	*Helianthus annus* L.	SUNF	37	9	115
		Pulses			
Adzuki bean	*Phaesolus angularis* Wight	ADZU	2	1	0
Fababean	*Vicia faba* L.	FABA	6	6	23
Field bean	*Phaeseolus vulgaris* L.	BEAN	526	597	14 546
Field pean	*Pisum* sp.	PEA	20	5	66
Garbanzo bean	Cicer arientinum L.	GARB	10	5	40
Lentil	*Lens esculenta* Moench. J.	LENT	8	6	36
Lupine	*Lupinus* sp.	LUPI	6	3	10
		Roots and tubers			
Potato	*Solanum tuberosum* L.	POTA	324	51	775
Sugarbeet	*Beat vulgaris* L.	S_BE	68	90	316
Total			4 748	2 942	46 674

When trial characteristics are filtered, SELECT! stores the identification numbers of the trials selected through the filter. Likewise, SELECT! stores the identification numbers of the varieties in the current array. The trial and variety identification numbers are used to extract matching records in the performance file.

Since the databases are normalized, data base maintenance is relatively simple. Because of the parent-child relationship of the data sets, data are entered only once. The linking variables VAR_ID and TRI_ID are entered more than once.

Traditional expert system software emulates the reasoning process of the software development individual or team (Meyer, 1990). SELECT! was written for user flexibility. The user, rather than the expert, software developer, or extension specialist, selects varieties and environments to summarize. This flexible approach has limitations, especially when the user does not clearly understand principles of variety selection.

Operation

User interaction with the software is initiated by various program procedures arranged in pull-down menus (Fig. 2). Procedures manipulate information contained in the crop database files. Procedures are grouped into Crop, Varieties, Environments, Performance, Agronomy and Utilities.

Only six keys are required to operate the program. The arrow keys position the cursor within pull-down menus and lists. The <RETURN> key selects items. The <ESC> key exits the procedure. Message prompts assist the user. The light bar cursor can also be positioned within a menu by pressing the first letter of the procedure. Other shortcuts using function keys are available. To exit the program, press <ESC> until back to the DOS prompt.

To begin SELECT!, the user identifies a crop within the <Crop> procedure. Once the crop is identified SELECT! is initialized with a variety array, a trial array, and a check variety. These initialization parameters are specified by an

extension specialist. The variety array consists of a list of varieties, usually those which are widely grown or high performing. The trial array is a list of trials over which performance will be summarized. The initial check variety is widely tested in agricultural experiment station trials, although any variety can be used as a check variety. The initialization parameters are indicated in a special status window on the main screen. Databases for 43 crops have been developed for SELECT! (Table 1).

The <Varieties> procedure develops a variety array to investigate. The array is a list of varieties the user is interested in comparing with a check variety. Variety arrays can be picked by variety name or by filtering using traits such as disease resistance. Varieties in the array with the selected trait can be further filtered for a different trait. Variety descriptions can be displayed to the screen, as can selected varieties and the trials where they were tested.

The <Environments> procedure allows the user to select environments to summarize variety performance. Usually, varieties are summarized by location. <Environments> allows data summarization by one or several trial descriptors such as soil type, planting date, fertility level, location, cropping system, year, soil test texture, soil test pH, altitude, etc.

Within the <Performance> procedure group, the user can select any check variety picked from the crop variety database. Generally, check varieties are familiar to the user. Other performance measurements such as plant height, protein, etc., can also be evaluated. The results of any trial can be displayed to the screen. Performance of varieties when grown in the same trials as the check variety can be summarized, compared, and printed.

General information and specific recommendations for production of the crop selected are found in the <Agronomy> procedure. These ASCII files are manipulated by searching for key words in each section. Information is grouped into subject areas and can be accessed by pull-down menus. For example, recommendations on pest control, other pertinent references, and seed sources within the Wyoming Crop Improvement Association can be displayed or printed.

The <Utilities> procedure performs editing and data entry. This procedure contains a word processor for modifying recommendations and xbase emulator for data editing and entry. Any word processor which saves files in ASCII format can be used to edit the Crop Agronomy files. Help for term definitions is available by pressing F1.

Data Maintenance

A significant issue for using the computer to select crop varieties is data maintenance. Crop variety development is dynamic. New information must be updated and appended to the databases since performance trials are annually conducted by the agricultural experiment station, new crop varieties are released, and new information about crop production is continuously developed. Updated crop databases in SELECT! can be retrieved by registered users from the University of Wyoming Cooperative Extension Service Bulletin Board via modem, or they can be obtained on a floppy disk for a nominal fee.

SPECIFICATIONS

SELECT! was written in Clipper and C programming languages. SELECT! requires an IBM PC, XT or AT, or a 100% IBM compatible computer (Table 2). The computer
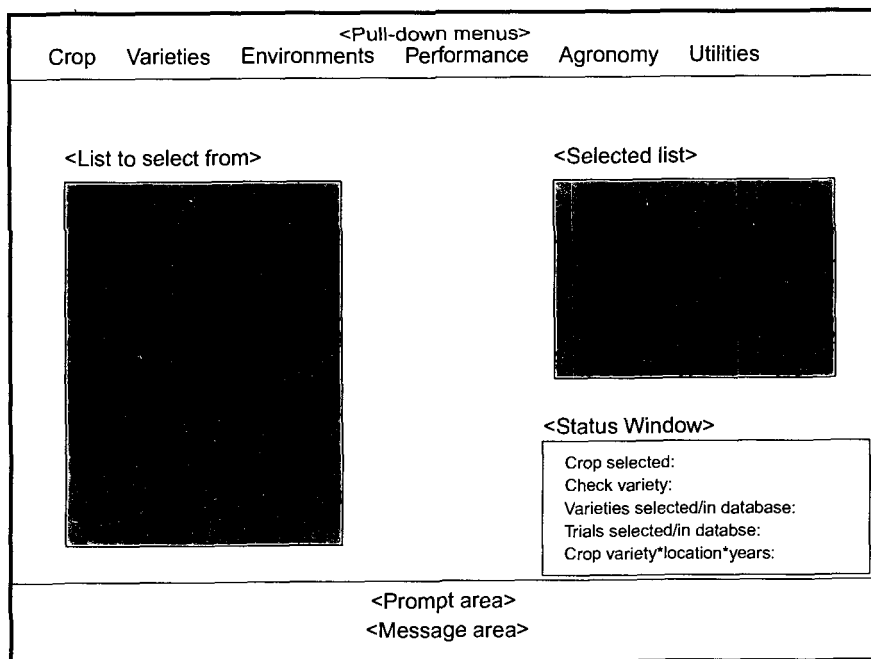

Fig. 2. Computer screen user interface of SELECT!

Table 2. Specifications of SELECT!

Database driver
    dBase-superset data files
    Up to 1 billion records per data file
    Up to 1024 fields per record
Field formats
    Character fields: up to 32 K characters (fixed length)
    Numeric fields: up to 30 digits (accuracy >16 significant digits)
    Data fields: 8 digits (01/01/0100–12/31/9999)
    Logical fields: 1 character
    Memo (variable length) fields: up to 64K characters.
Maximum open data files: 250 (limit:available file handles)

must include the following features: (i) PC-DOS or MS-DOS Version 3.1 or greater, (ii) 384K, or more, of Random Access Memory (RAM), (iii) one diskette and one hard disk drive, (iv) ANSI terminal support, (v) a printer, and (vi) a math co-processor chip. In general, the faster the micro-processor of the computer, the better SELECT! will perform. SELECT! has virtual memory capabilities that will automatically use RAM, expanded memory, and, if necessary, hard disk space. The virtual memory manager provides up to 64 megabytes of accessible memory space, effectively removing any practical limitations on the memory requirements of SELECT!

DOCUMENTATION AND AVAILABILITY

SELECT! is distributed and licensed by the University of Wyoming, Cooperative Extension Service Publications Office, P.O. Box 3354, University Station, Laramie, WY 82071. The $45 price includes a user's manual and 3.5 in. diskettes containing the executable file and data files. Updates of data files are available on 31 December of each production year. Updates can be obtained by disk or downlinked via modem from the University of Wyoming Cooperative Extension Bulletin Board Service. For further information, contact Joseph G. Lauer, University of Wyoming, 747 Road 9, Powell, WY 82435. Registered users are advised of all future updates and new versions and are encouraged to make suggestions for each forthcoming version.

ACKNOWLEDGEMENTS

Disclaimer

Trade or brand names are used only for educational information. The information given herein is supplied with the understanding that no discrimination is intended and no endorsement by the Wyoming Agricultural Experiment Station is implied.

REFERENCES

Anonymous. 1992. Germplasm resources information network: User's manual. USDA-ARS Plant Sci. Inst., Natl. Germplasm Resources Lab Database Management Unit, Beltsville, MD.

Ashlock, L.O., R.L. Bridges, D.G. Dombek, T.C. Keisling, and R.P. Nester. 1991. SOYVA—A computerized soybean cultivar selection program. p. 73. In Agronomy abstracts. ASA, Madison, WI.

Boyer, C.F., and J.H. Palmer. 1984. BEAN-AID, a computer assisted soybean production and marketing guide. p. 48. In Agronomy abstracts. ASA, Madison, WI.

Carlson, J.R., and D.B. Hannaway. 1984. FOREC: Forage seeding recommendations for Oregon. p. 49. In Agronomy abstracts. ASA, Madison, WI.

Carrascal, M.J., and L.F. Pau. 1992. A survey of expert systems in agriculture and food processing. AI Applications 6:27–49.

Farrell, R.A., C.J. Pearson, and L.C. Campbell. 1992. Relational databases for the design and construction of maintainable decision support systems in agriculture. Agric. Syst. 38:411–423.

Hannaway, D.B., A. Maristany, R.W. Linares, and P.E. Shuler. 1984. ALFACHAR—A data base of alfalfa variety characteristics. p. 50. In Agronomy abstracts. ASA, Madison, WI.

Helsel, Z.R., and S.J. Burns. 1984. Soybean variety and information selection program. p. 50. In Agronomy abstracts. ASA, Madison, WI.

Iddings, R.K., and J.W. Apps. 1990. What influences farmers' computer use? J. Ext. 28(Spring):19–21.

Kephart, K.D., R.S. Karrow, and B.C. Miller. 1989. GrainVar—A program to aid selection of small grain varieties in the Pacific Northwest. p. 66. In Agronomy abstracts. ASA, Madison, WI.

Meyer, C.R. 1990. Minimum user-interface standards and software for agricultural expert systems. Agron. J. 82:647–650.

Shroyer, J.P., S.C. Young, M.C. Knapp, T.S. Cox, and S.M. Welch. 1986. Wheat Wiz: Selecting a wheat variety using an expert system. p. 52. In Agronomy abstracts. ASA, Madison, WI.

Thien, S.J., and W.T. Schapaugh. 1992. SoySelect: Soybean cultivar selection software. p. 84. In Agronomy abstracts. ASA, Madison, WI.

Thomison, P.R., and G.W. Short. 1988. SPG88—A computer assisted soybean production guide for use in extension. p. 69. In Agronomy abstracts. ASA, Madison, WI.

Wisiol, K., and G.E. Pepper. 1986. Expert-system microcomputer program for soybean variety choice. p. 53. In Agronomy abstracts. ASA, Madison, WI.