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ONVAREF: A decision support system for onion varietal reference

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This paper presents the development of a decision support system (DSS) called ONVAREF for screening of new onion varieties being released. The system is a windows oriented, user-friendly, database driven, having excellent graphical user interface (GUI), designed using 4GL, which works on searching and matching principle to spawn large database comprising of dozens of characteristics suitable for judging originality of a variety under screening. It is also capable of assessing closeness of existing varieties with the one being screened. The accuracy of decision making process provided by ONVAREF has been found 93.33% as compared to 53.33% by manual screening. It is 123% time efficient as compared to paper based assessment manual from which the computer programme was evolved.

Key words: Decision support system, modeling, database driven decision support system (DSS), database management system (DBMS), decision making.

INTRODUCTION

Screening of newly developed onion varieties amidst ever-increasing duplicacy of research effort is a complex process that demands evaluation of many characteristics having different parameters. There is a substantial amount of empirical evidence that human initiative judgment and decision making can be far from optimal and it deteriorates further with added complexity and stress (Adams et al., 2000). In this situation, the precision of human judgment and decision making is very important. Design and development of tools and techniques aiding agricultural decision process is gaining popularity, particularly with the advancement in electronically processing of data (Power, 2002). Decision support systems can help to reduce uncertainty and improve decision-making process by providing access to data through procedures and analytical reasoning (Uehera and Tsuji, 1993). For agriculture production and marketing of sustainable development, decision support system (DSS)'s have allowed rapid assessment of several production systems around the world to facilitate decision making at farm and policy levels.

The concept of decision support system research has evolved from technical studies of organization decision making and technical work on interactive computer system, mainly carried at Massachusetts's Institute of Technology (MIT) in 1960s (Keen et al., 1978). It became recognized as self sustained research area widely in the 1970s and gained high reputation in the 1980s. Data warehousing and Online Analytical Processing (OLAP) further broadened the realm of DSSs in 1990s. Arrival of

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new millennium introduced web based analytical applications, giving DSS an important role in decision making process.

The applications of DSS seem natural considering the widespread use of decision making agents in and out of the field. With the advent of powerful computational power, efficient database management system (DBMS) with OLAP, computer programs aimed to support decision process has improved a lot. These systems have already been applied in different areas of agriculture (Jenkins and Williams, 1998), such as Crop-Protection, Agronomy, Plant Pathology, Pomology, Soil Science, Agricultural Engineering, Forestry, Environmental Science, Agro meteorology among others, and have the potential to be an important tool in the decision making process for primary producers and their advisors (Ritchie, 1995).

Use of DSS in agriculture for providing information and recommendation on efficient utilization of fertilizer (Chai et. al., 1994), reducing herbicide use (Coble, 1994), plant protection (Yialouris et al., 1996), variety specific information (Detlefsen et al., 2004), management of environment risks (Didier, 2005), integrated nutrient management (Mosseddaq, 2005), forest management (Rui and Jose, 2005), crop disease control (Tagir et al, 2005), agricultural practices and extension (Suarez et. al., 2005) and sustainable land use planning (Klik, 2006) have been designed and implemented successfully mainly for improving economic returns, changing farming practices and minimizing environmental risks.

Division of Vegetable Science, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir (SKUAST Kashmir) acted as nodal centre for screening of onion varieties. The process was manual based and results were always error prone, resulting in inefficient decision making. Realizing the need of error free and quality decision in screening process viz-a-viz potential and successes of agricultural decision support systems, ONVAREF was designed and developed for quality decision making to discourage duplicity of research effort. The system is database driven having efficient graphical user interface, with options to generate reports and proper validation checks. It has been build based on the manual which consists of tens of evaluation characteristics having hundreds of parameters sufficient to distinguish one onion variety with the other. The system has incorporated 19 existing varieties of onion, along with their evaluation characteristics, which were existing at the time of system development. The system has a provision to include newly release varieties along with their physio-chemical characteristics.

Decision support systems (DSS)

DSS are interactive, computer-based systems and subsystems intended to help decision makers to use communication technologies, data, documents, knowledge and/or models to complete decision process tasks, giving emphasis to structural, semi-structured and unstructured decisions (Keating and McCown, 2001; Yialouris et al., 1997). They can improve the quality and effectiveness of decision making by processing a lot of data and providing alternative solutions. The term DSS has been used and defined in various ways depending upon the author's point of view (Power, 2002; Druzdzel and Flynn, 1999). Finlay (1994) defined it as "a computer-based system that aids the processing or decision making". While Turban (1995) defined it specifically as "an interactive, flexible, and adaptable computer based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making". There are also several definitions given by different authors, which fall between these two extremes (Little, 1970; Keen and Scott, 1978; Moore and Chang, 1980; Sprague and Clarlson, 1982). In order to avoid exclusion of any of the existing types of DSSs, we define them roughly as interactive computer based systems that aid in making a quality decision.

Overview of DSS

Researchers and technologists have built and investigated DSSs for about 48 years. This concept has evolved from technical studies of organizational decision making and technical work on interactive computer systems mainly carried at Massachusetts's Institute of Technology (MIT) in 1960s (Keen and Scott Morton, 1978). The first DSS for agriculture cited in the literature is *Televis*, which was developed by Norway in 1957 for plant protection. Another such system named as *Guntz-Divoux* was developed by France in 1963. First computer-aided DSS for production scheduling was investigated, which was running on IBM 7049 (Ferguson and Jones, 1969). Michael S. Scott Morton's dissertation in 1967 is regarded as major historical turning point wherein building, implementing and testing an interactive and model-oriented DSS. During 1971 Scott Morton demonstrated "how computer and analytical models could help managers to make key planning decisions". DSS became recognized as self-sustained research area in 1970s, when business journals started publishing articles on management decision systems, strategic planning systems and decision support systems (Sprague and Watson, 1979). DSS gained high reputation during 1980s when its application development started in Universities and organizations, which expanded their scope. During 1982, Ralph Sprague and Eric Carlson's book "Building Effective Decision Support System" further explained the framework of database, model base, dialog generation and software management. It provides a practical and understandable overview of how organization could or should build DSS.

Table 1. Existing onion varieties incorporated in the ONVAREF.

S/N	Onion variety
1	Panjab Naroya
2	B4
3	Phule Suvarna
4	Arka Niketan
5	Pusa Madhavi
6	Pillpatti Local
7	Agrifound Light Red
8	Gujarat White Onion
9	Hisar-2
10	VL-3
11	Arka Pragati
12	Udaipur-102
13	Yello Globe
14	PRO-6
15	Pusa White Round
16	N-2-4-1
17	Pusa red
18	Arka Pitambar
19	Agrifound Rose

During 1990, Bill Inmon, father of data warehouse, and Ralph Kimball, the doctor of DSS, actively promoted DSS development using relational database technologies.
Beginning in approximately 1995, the WWW and global Internet provided a technology expansion platform for further extending the capabilities and deployment of computerized decision support. In 2000, Application Service Providers (ASPs) began hosting the application software and technical infrastructure for decision support capabilities. Emergence of enterprise knowledge portals, knowledge management, business intelligence and communication technologies integrated DSS to an integrated environment (Bhargava and Power, 2001). Most software developers have regarded WWW as a serious platform for implementing all types of DSSs. Manipulation of quantitative models, accessing and analyzing of large databases and building of group DSSs are major applications of DSS (Ecom, 2002; Arnott and Pervan, 2005). Recently, intelligent decision support systems have added new capabilities to these systems (Dhar and Stein, 1997).

MATERIALS AND METHODS

Development and evaluation of Agricultural DSS has widely been documented in literature (Renner et al., 1999). However design, development and evaluation of ONVAREF follows as related research (Batchelor et al., 2004a; Hochman et al., 1994; Cox, 1996; Jakku,and Thorburn 2010; Adelman, 1992). Data design comprises of 30 parameterized characteristics already identified by the domain experts pertaining to 19 already existing onion varieties (Tables 1 and 2).

In order to study the accuracy of DSS with respect to manual procedure, 100 trial cases each involving Domain experts, who used to screen onion varieties using manual procedure and those who got trained to use DSS instead of manual procedure were conducted. The maximum scores that an evaluator could obtain was 109 (109 option corresponding to 30 characteristics) and the minimum score that a respondent could obtain was 0. The accuracy index was calculated based on the following formula

$$\text{Accuracy index} = \frac{\text{No. of correct options taken into consideration}}{\text{Total options}} * 100$$

Data analysis has been done using R software.

System design

The technical structure of ONVAREF-DSS is designed in a way that allows interactive operations of the decision maker without any specific knowledge. The DSS output includes recommendations on originality of variety, its closeness with other existing varieties, cultivation and management practices and all attributes that makes evaluation of onion variety possible.

The system has been developed using Microsoft Visual Basic as front end tool (Graphical User Interface (GUI), with embedded SQL statements) and Microsoft Access as backend to handle structure of database and data. The chosen languages Visual Basics and Structured Query Language (SQL) provides more than three times and nine times, respectively, the functionality of a LOC than other conventional languages. The comparison characteristics of different languages used as front end and back end have been given in literature (Jones, 1998).

All the database operations have been implemented through SQL calls embedded in Microsoft Visual Basics. For data entry and reports, interactive Microsoft Visual Basics forms and reports have been used. We have also used the Microsoft Jet Database Engine

Table 2. Characteristics of Onion varieties incorporated in ONVAREF.

S/N	Onion varieties
1	Foliage attitude
2	Bulb width of neck
3	Time of harvesting
4	No. of leaves
5	Bulb colour of skin
6	Leaf maximum diameter
7	Foliage length
8	Bulb thickness of rings
9	Leaf waxiness
10	Leaf glossiness
11	Bulb colour of flesh
12	Leaf colour
13	Foliage / leaf cranking
14	Bulb diameter of root disc
15	Leaf foliage fall
16	Pseudo stem diameter
17	Pseudo stem length
18	Bulb diameter
19	Bulb cross section
20	Bulb bolting tendency
21	Bulb height
22	Bulb shape
23	Bulb thickness of skin
24	Bulb skin adherence
25	Bulb firmness of flesh
26	Bulb position of root disc
27	Bulb pred. no. of axes
28	Bulb dry matter content
29	Splitting note bulb lets
30	Seasonal adaptability

for connectivity between form end and back end. The connection is dynamic with automatic configuration at the time of installation.

Knowledge representation

Knowledge representation has been expressed as a series of IF/Then statements, which are mostly followed in development of decision support systems (Gonzalez-Andujar, 1993). The rule is made up of a list of IF conditions(s) and a list of THEN conclusions(s) or statement(s) about the appropriate solution of the problem. If the computer determines that certain IF condition is true, it executes THEN statement(s) and draws conclusion(s) in the form of statement(s). Knowledge base of ONVAREF is implemented as a set of tables designed used in a proper schema.

System architecture

The ONVAREF is database driven, singly user system. The front end side consists of a GUI, rule-based reasoning and interface engine. The back end handles storage using the capabilities of a DBMS. The DBMS performs the ordinary DB operations such as insert, select, delete and update. GUI accesses the DBMS using embedded SQL statements to alter or get results. The Modular structure and interface description of ONVAREF has been shown in Figures 1 to 4 and Entity_Relationship Diagram (ER- Diagram) is shown in Figure 2. The historical evolution of the DBMS are described in Date (1995).

RESULTS AND DISCUSSION

100 trial cases each involving Domain experts who used to screen onion varieties using manual procedure and those who have closely watched the development of the system were involved to run many trial cases. The results of the trial cases are presented in Table 3 which testifies the accuracy of the system. Error-free decisions made by DSS were 93.33% as compared to 53.33% while 10% errors were reported in 4 cases (6.67%) as compared to 21 cases (35%). Also no case was reported in which more than 10% errors could be seen using DSS as compared to 7 cases (11.67%) using manual procedure.

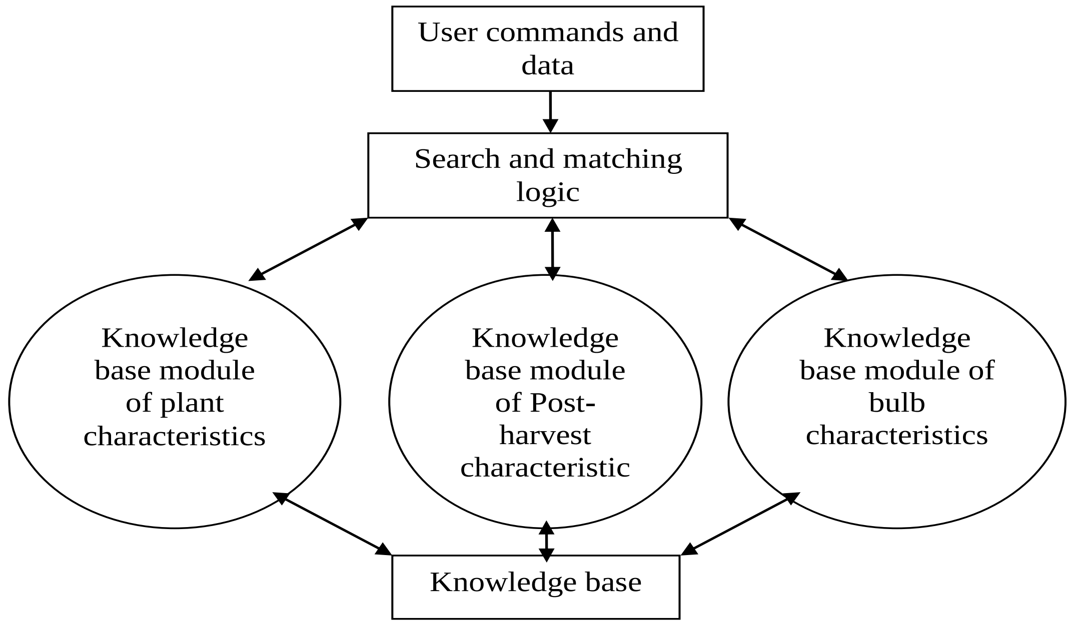

Figure 1. Modular structure and interface description of ONVAREF.

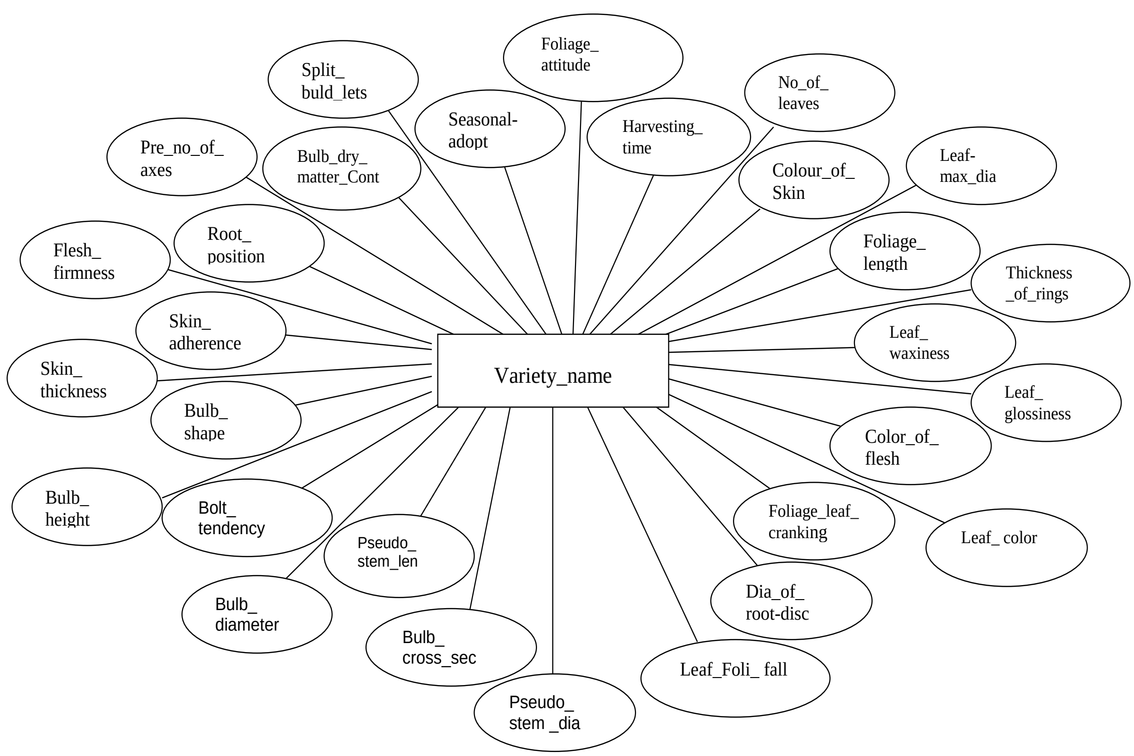

Figure 2. Entity-relationship diagram.

It also clearly indicates that system is considerably reducing workload and saving time (138%) related to variety evaluation / screening process, as and when made accessible. The perception of the users about using ONVAREF is given in Table 4. It is evident that more than 10% users have rated usefulness and

Table 3. Distribution of trial-cases results about accuracy of ONVAREF Vs manual procedure.

Parameter	Using ONVAREF (N=60)		Using manual procedure (N=60)	
Mean score	108.83		103.08	
Standard deviation	0.69		9.04	
Range	105 – 109		72 – 109	
Average time taken for screening of one variety	09.7 min		21.67 min	
Decision	**No.**	**Percent**	**No.**	**Percent**
No errors	56	93.33	32	53.33
Up to 10% errors	4	6.67	21	35.00
More than 10% errors	0	0	07	11.67
Total	60	100	60	100

Table 4. Distribution of end-users based on their perception about utility of ONVAREF.

Particular	(N = 60)		
	Excellent	**Good**	**Fair**
Usability	9 (15%)	48 (80%)	3 (5%)
Portability	8 (13.30%)	51 (85.00%)	1 (1.70%)
Extendability	5 (8.30%)	55 (91.70%)	0 (0.00%)
Usefulness	12 (20.00%)	42 (70.00%)	6 (10.00%)
Operateability	3 (5.00%)	57 (95.00%)	0 (0.00%)
Adoptability	13 (21.70%)	35 (58.30%)	12 (20.00%)

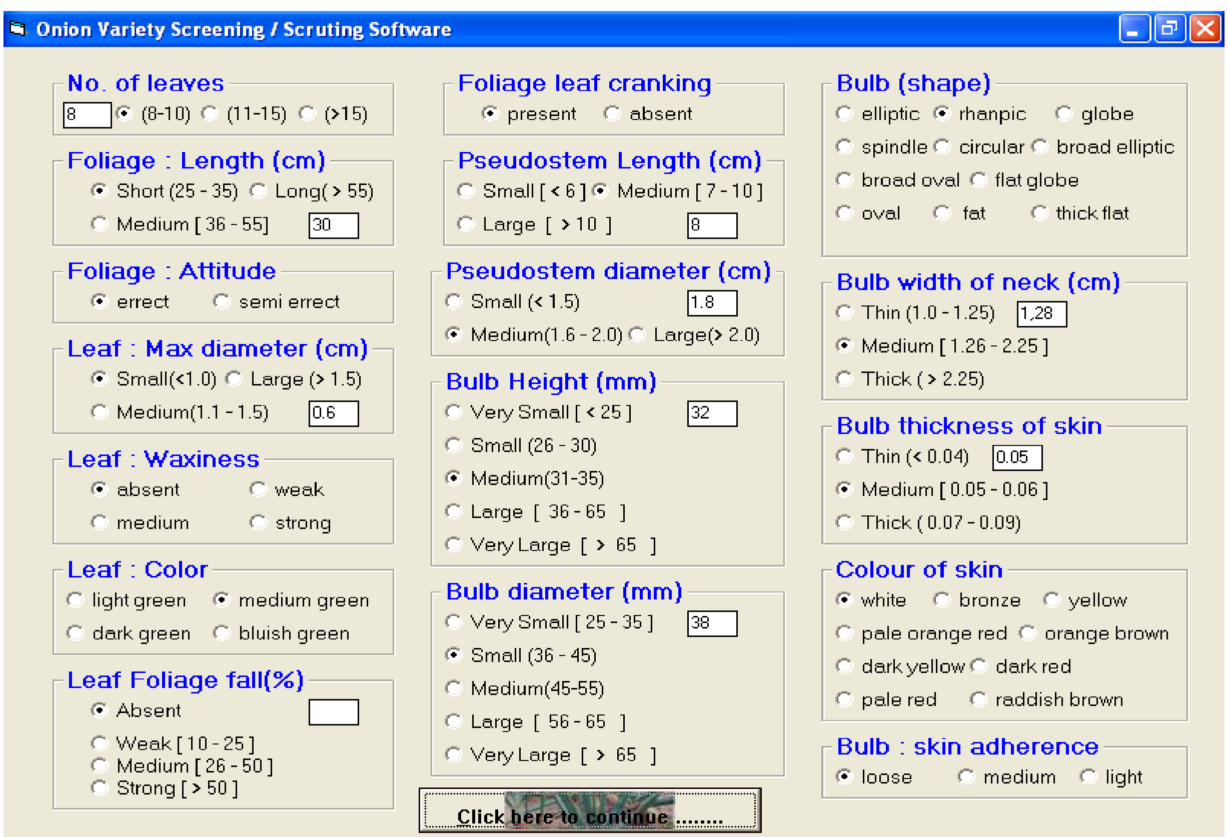

Figure 3. User interface of ONVAREF -1.

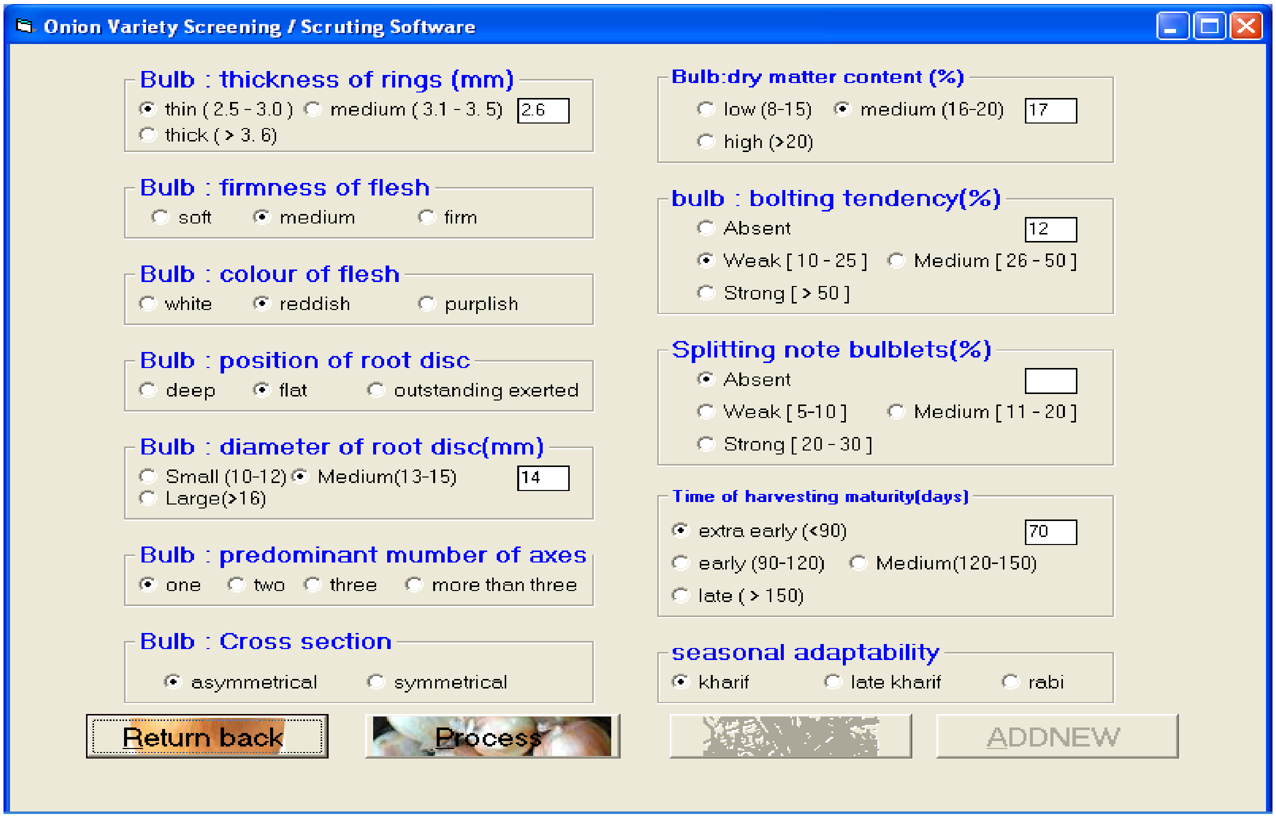

Figure 4. User interface of ONVAREF-2.

adoptability as excellent while the rest have been rated from 3-9%. Also more than 50% users have rated usability, portability, extendability and operateability as good while more than 40% users have rated usability and usefulness as good. Moreover, nearly 12% users have rated adoptability as fair. The results are in agreement with the recommendations given by various researchers regarding design, development, evaluation and implementation of agricultural DSS viz, user friendly, portable, useful, extendable, with maximum adoptability score, which most of the agricultural based DSS lacks. (Hochman et al., 19940; Renner et al., 1999 and Cox PG, 1996)

Conclusion

ONVAREF has been successfully implemented for screening process of newly developed onion varieties. It has proved to be accurate, time saving, as well as ascertaining closeness of particular variety under screening with the existing one which has paved the way to put the variety under more screening process before releasing recommendation, which was not possible with the manual procedure being used. In short, design and development of ONVAREF is an effort towards quick, timely and reliable decision support for evaluation of Onion varieties mainly to discourage duplicacy of research effort.

Abbreviations: DSS, Decision support system; **OLAP,** online analytical processing; **DBMS,** database management system; **ASPs,** application service providers; **SQL,** structured query language; **GUI,** graphical user interface.

REFERENCES

Adams ML, Cook SE, Corner R (2000). Managing Uncertainty in Site-Specific Management: What is the Best Model? Prec. Agric. 2:39-54.
Adelman L (1992). Evaluating Decision Support Systems and Expert Systems. New York Wiley.
Arnott D, Pervan G (2005). A critical analysis of decision support systems research. J. Inform. Technol. 20(2):67-87.
Batchelor WD, Paz JO, Thorp KR (2004a). Development and evaluation of a decision support system for precision farming. Proceedings of the 7th International Conference on Precision Agriculture. July 25-26, 2004, Minneapolis, MN. ASA, CSSA, SSSA Inc., Madison, WI, USA.
Bhargava H, Power DJ (2001). Decision support systems and web technologies: a status report. In: Americas Conference on Information Systems, 3-5 August 2001, Boston, MA.
Chai KL, Costello TA, Wells BR, Norman RJ (1994). Expert system for fertilization management of rice. App-eng-agric. 10:849-855.
Coble HD (1994). Computer decision aids for reducing herbicide use. Proc-annu-meet-Northeast-weed-sci-Soc. College Prak, Md.: The

Society. 48:155-159.

Cox PG (1996). Some issues in the design of agricultural decision support systems. Agric. Syst. 52(2-3):355-381.

Date CJ (1995). An Introduction to Database Systems, 6th Edition, Eddison-Wesley, 1995.

Detlefsen NK, Jensen AL (2004). A stochastic model for crop selection. Agric. Syst. 81(1):55-72.

Dhar V, Stein R (1997). Intelligent Decision Support Methods: The Science of Knowledge. Prentice-Hall, Upper Saddle River, NJ.

Didier B, Christophe LP, Souleymane D, Geraldine A (2005). Perspectives of modelling the farmer's seed system for in situ conservation of sorghum varieties in Mali. Paper presented at EFITA/WCCA, 2005, 25-28 July 2005, Vila Real, Portugal.

Druzdzel MJ, Flynn RR (1999). Decision Support Systems. Encyclopedia of Library and Information science. A. Kent, Marcel Dekker, Inc.

Ecom SB (2002). Decision Support Systems Research (1970-1999). Edwin Mellen Press, Lewiston, NY.

Ferguson RL, Jones CH (1969). A Computer Aided Decision System. Manage. Sci. 15(10):550-562.

Finlay PN (1994). Introducing Decision Support Systems. Blackwell Publishers, Oxford, UK; Cambridge, MA.

Gonzalez-Andujar JL (1993). Cereal aphids expert system (CAES): Identification and decision making. Comput. Electr. Agric. 8:293-300.

Hochman Z, Pearson CJ, Litchfield RW (1994). User's attitude and roles in the development and evaluating of Knowledge Base Decision Support System for agricultural advisors. Agric. Syst. 44(2):217-235.

Jakku E, Thorburn PJ (2010). A conceptual framework for guiding the participatory development of agricultural Decision Support Systems 103(9):675-682.

Jenkins TG, Williams CB (1998). DECI-Decision evaluator for the cattle industry. In: Proc. 6th World Cong. Genet. Appl. Livest. Prod. Armidale, Austr. 27:461-462.

Jones C (1998). Estiamting Software Costs, McGraw-Hill, 1998.

Keating BA, McCown RL (2001). Advances in farming systems analyses and intervention, Agric. Syst, 70:555-579.

Keen PGW, Scott Morton MS (1978). Decision Support Systems: An Organizational Perspective. Reading, MA: Addison-Wesley.

Keen PGW (1980). Decision support systems: a research perspective. In: Fick, G.1258 and Sprague, R. H. (Eds.), Decision Support Systems: Issues and Challenges. Pergamon Press, Oxford; New York.

Klik A (2006). Agricultural Decision Support System for Soil and Water Conservation Measures. Computer in Agriculture and Natural Resources, 4th World congress conference, proceedings of the 24-26 July 2006 (Orlando, Florida USA) Publication Date 24 July 2006 701P0606.

Little JDC (1970). Models and Managers: The Concept of a Decision Calculus. Manage. Sci, 16(8).

Moore JH, Chang MG (1980). Design of Decision Support Systems. Data base, 12(1&2).

Mosseddaq F, Dnidane S, Lahlou M (2005). Integrated Wheat N Nutrition Management in Morocco: A Decision Support Model Paper presented at EFITA/WCCA, 2005, 25-28 July 2005, Vila Real, Portugal.

Power DJ (2002). Decision Support Systems: Concepts and Resources for Managers. Greenwood/ Quorum, Westport, CT.

Power DJ (1997). What is a DSS?. DSstar, The On-Line Executive J. Data-Intensive Decision Support, 1(3).

Renner KA, Swintin SM, Kells JJ (1999). Adaptation and evaluation of the WEEDSIM weed management model for Michigan. Weed Sci. 47:338-348.

Ritchie JT (1995). International consortium for agriculture Systems Application (ICASA): Establishment and Purpose. Agric. Syst. 49:329-335.

Rui PR, Jose GB (2005). MetaForest- a web-based decision system to support forest management involving multiple-ownership. Paper presented at EFITA/WCCA, 2005, 25-28 July 2005, Vila Real, Portugal.

Sprague Jr. RH, Watson HJ (1979). Bit by Bit: Toward Decision Support Systems. California Manage. Rev. 22(1):60-68.

Sprague Jr, RH, Carlson ED (1982). Building Effective Decision Support Systems. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Suarez de Cepeda, Recio M, Rubio, F (2005). Decision Support System for Farm Mechanization. Paper presented at EFITA/WCCA, 2005, 25-28 July 2005, Vila Real, Portugal.

Tagir Z, Ibragimov I, Ibragimova T, Sergey SS (2005). Decision Support Systems for Cereal Crop Disease Control. Paper presented at EFITA/WCCA, 2005, 25-28 July 2005, Vila Real, Portugal.

Turban E (1995). Decision support and expert systems: management support systems. Prentice Hall, Englewood cliffs, NJ.

Uehera G, Tsuji GY (1993). The IBSNAT project. In: Systems approach to agricultural development. Penning de Vries, F.W.T., Teng, P.S. (eds.) Kluwer Academic Publishers, The Netherlands. pp. 505-514.

Yialouris C, Kollias V, Lorentzos N, Kalivas D, Sideridis A (1997). An Integrated Expert GIS for Soil Suitability and Evaluation. J. Geogr. Inform. Dec. Anal. 1:90-100.

Yialouris CP, Sideridis AB (1996). An expert system for tomato disease. Comput. Electr. Agric. 14:61-76.