Selecting Barley Variety through Expert System

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Abstract- Disseminating technologies through traditional methods are time consuming and a costly proposition. Recent developments in information communication technologies can play an important role in faster transfer of technologies in a cost efficient manner. An expert system on barley crop management was developed to help barley growers and extension workers to suggest suitable technologies. To develop the expert system, Active Server Pages (ASP) had been used with forward and backward chaining technique. Suggestions given by the farmers, extension workers and barley experts had been used in developing the expert system. The expert system has been designed for four modules on variety selection, plant protection, cultural practices and harvesting management and the present paper deals with the varietal selection module to provide state wise, zone wise, type of barley i.e. malt barley, food barley, fodder barley, dual purpose information. The program can be used as an expert by farmers, extension workers and technicians for educational purposes for faster dissemination of expert advice at distant locations.

Index Terms- Expert System, Barley, Variety Selection.

I. INTRODUCTION

Barley is widely grown in rabi season (winter) in Rajasthan, U.P., M.P., Punjab, Haryana, and Bihar in plains and Himachal Pradesh, Uttarakhand and Jammu & Kashmir in the hills and requires low input and it is adaptable to adverse production conditions. Barley occupies nearly 0.699 million hectare area producing nearly 1.743 million tons grain with a per hectare productivity of 2516 kg (4th Advance Estimate 2012-13). Despite of decline in area in the initial phase, there is stability in the area sown during the past 15-20 years with minor annual fluctuations.

The barley area declined during the green revolution period mainly due to development of semi-dwarf wheat varieties with high yield potential compared to barley crop. Lack of major breakthrough in barley also made the crop to suffer. The area further declined after the green revolution phase because of development of irrigation network and wheat became an important crop for food security of India.

About 25-30% of the total barley production is used for malt and malt extract, which is further utilized for brewing, distillation, baby foods, cocoa-malt drinks and medicinal syrups. Rest of the production is utilized as cattle feed, cereal food and in preparation of local beverages in the tribal areas. To promote the cultivation of malting type cultivars, private companies have initiated "Contract Farming" in states like Punjab, Haryana, UP and Rajasthan to ensure continuous supply of the raw material (malt barley grain) to meet the growing demand of malt for brewing and confectionary items. Contract farming has a positive impact on popularization of malt barley cultivation (Singh et al 2012). These private organizations can not employ many extension workers, therefore, expert system can help them to transfer barley production and protection technologies in an efficient manner.

In the present scenario, there are about one lakh extension workers in India and the system demands a lot more to have personal contact with the farmers which is too cost intensive and time consuming. The traditional approach of personal contact has given a way to the modern approaches like ICTs, which are more efficient. Despite of a large network of State Department of Agriculture, KVKs, ICAR institutes, NGOs, input dealers, Department of Agriculture and Cooperation, Agricultural Universities and private institutions, it is difficult to contact each and every farmer personally. Due to scarcity of manpower and expertise to transfer the technologies, the policy makers and researchers always blame the existing extension system for poor transfer of technologies. Efforts were made earlier to develop expert systems on various crops. NEPER wheat expert system was one of the expert systems developed at Central Laboratory of Agricultural Expert System (CLAES) in Egypt (Edrees *et al*. 2003). WHEATWIZ, an expert system developed in 1987 in variety selection for hard red winter wheat (Zhang 1992), Ravisankar *et al.* (2010) developed the expert system for abiotic stresses in tobacco and Islam *et al.* (2012) on wheat crop. No effort was made in India to develop expert system on barley crop.

The expert system in barley has the expertise of different subject matter specialists. These systems have the capability to answer relevant questions and explain its reasoning process and will be able to interact with farmers and end users in a way that can be understood by them. The expert system will provide right information to the farmers at right time, to plan their operations and take decisions (Islam *et al* 2012). An effort has been made to develop the "Expert System on Barley Crop Management" dealing with variety selection.

II. MATERIALS AND METHODS

Expert system for barley crop has been developed using programming language in a suitable programming environment (Active Server Pages technology). The programming environment gives the flexibility to the developer to have a total control over the system. **ASP** is a server scripting language. ASP as server side scripting language has a control on web application logic. The application logic is what you handle using "if conditions"

and "process flows" cases, this leads to a dynamic generation of HTML pages. The system is built using standard web technology and will be accessible globally on the web via internet. The main components of expert system include knowledge base, inference engine, and user interface. The system has been developed using 3-tier architecture that facilitates the three-way interaction in a client server environment.

a) The user interface is stored in the client (web-based)
b) The bulk of the application logic is stored on the server (IIS)
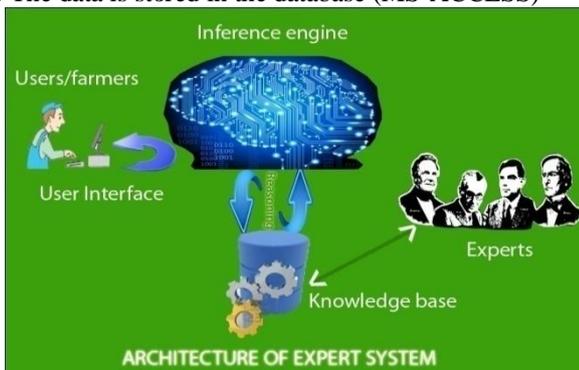c) The data is stored in the database (MS-ACCESS)

Fig 1: Architecture of Expert System

The barley expert system works on its powerful knowledge base which works at its core. On the basis of review of literature and interaction with barley research workers, farmers and extension workers, the module related to varietal selection was formulated. The collected information was used to develop the database for the Expert System. The requirement analysis was done in consultation with farmers and experts. Most knowledge was acquired from the experts using conventional interviewing techniques (Scott et al., 1991).

The typical knowledge base has been developed using MS-ACCESS that has stored information in the form of facts. The knowledge base is such prepared that it allows faster accessibility of the information to the user because it works on the particular code allocated uniquely to the available data (for example. Sowing condition SC, Irrigated IR, RAJASTHAN RJ …etc.) .The efficient knowledge is important in fact essential for an expert system to behave intelligently to provide accurate solution to the problems of the users.

Inference engine works on the logical reasoning, inference mechanism and working memory where information is temporarily transferred at the time of decision making. An **inference engine** is a computer program that tries to derive answers from a knowledge base. It is the "brain" that expert systems use to reason about the information in the knowledge base for the ultimate purpose of formulating new conclusions. Inference engines are considered to be a special case of reasoning engines. Two scripting languages Java Script and VB Script have been used to develop inference

engine by applying the desired rules and binding it with the knowledge base for extracting the required information through reasoning mechanism .The inference engine is trained on both of the reasoning methods that is forward chaining (data driven) for selecting the variety as well as backward chaining (goal driven) for selecting the information regarding particular variety that has been provided by the user. ***Proposed Architecture:***
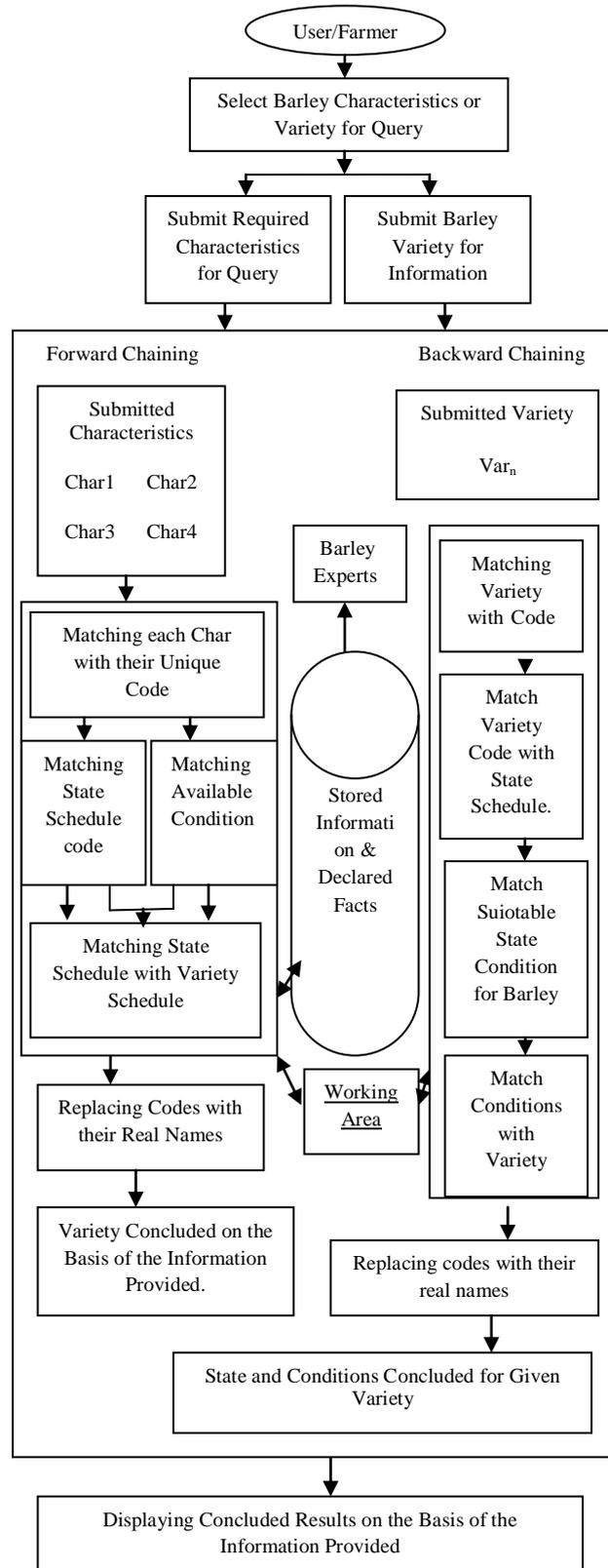
Computer based adaptive capabilities are essential in situations where environments change, in situations where standards of expertise are changing, and in situations where there are no historical data and learning occurs as a task that has been performed. One of the advantages of the rule based systems is that inference engine and knowledge base are separate. Knowledge base contains the information and is external to the inference engine and can easily be modified without changing inference engine mechanism.

This is a rule based expert system in which simple IF and THEN rules has been used. Any rule consists of two parts:
The IF part called the antecedent (condition) and the THEN part called the consequent (conclusion or action).

The antecedent of a rule incorporates two parts: an *object* and its *value*. The object and its value are linked by an *operator*. The operator identifies the object and assigns the value. Operators such as *is*, *are*, *is not*, *are not,* are used to assign a **symbolic value** to a linguistic object.

IF state is Rajasthan THEN variety is BH 393.

Sowing Condition		Sowing Period	
sowing_condition_code	sowing_condition	sowing_period_code	sowing_period
IR	Irrigated	ES	Early Sown
RF	Rainfed	LS	Late Sown
SI	Saline soils	NS	Timely Sown
		SI	Summer Irrigated
		VES	Very Early Sown
		VLS	Very Late Sown

state_name	state_code	purpose_code	purpose
Gujarat	GJ	FE	Feed
Himachal Pradesh	HP	FG	Feed and Green forage
Haryana	HR		
Jharkhand	JH	GF	Grain/Food
Jammu and Kashmir	JK	GR	Grain
		ML	Malt

Fig 2: Representation in Knowledge Base

The varieties can be selected on the basis of their several type of characteristics such as sowing conditions(SC), sowing period(SP), purpose(P), yield(YLD).The rules are formed such as:
IF state is Rajasthan and sowing condition is irrigated and sowing period is timely THEN variety is BH902.
Barley expert systems perform the selection of the barley variety through state-wise as well as through characteristics. State can be any of the 28 of India and it is represented as S1,S2,S3…. Sn where barley is grown.
Facts Defined:

F1: V_j is a barley variety.
F2: V_j Can be grown in irrigated conditions
F3: V_j Should be sown timely
F4: V_j is grown for Malt
Rules:
R1: If state is Haryana and crop is barley then variety V_j should be grown.
R2: If state is Haryana and crop is barley and sowing condition is irrigated then variety V_j should be grown.
R3: If state is Haryana and crop is barley and sowing condition is irrigated and sowing period is timely then variety V_j should be grown.
R4: If crop is barley state is Himachal Pradesh and purpose is malt then variety V_j should be grown.
Rn-1: If crop is barley and state is Madhya Pradesh then variety V_j should be grown.
Rn: If state is J&K and sowing condition is rainfed then variety V_j should be grown

State	Sowing Condition	Sowing Period	Purpose	Variety
Haryana	Irrigated	Timely Sown	Grain	BH 393
Rajasthan	Irrigated	Timely Sown	Feed	BH 902
Madhya Pradesh	Rainfed	Timely Sown	Feed	JB 58
Uttar Pradesh	Irrigated	Timely Sown	Feed	NB 3
Gujarat	Irrigated	Late Sown	Malt	DWRU B 64

Fig 3: Tabular Representation of Rules for Barley Variety

III. CONDITIONS FOR VARIETY SELECTION

SC - Sowing Condition
SP - Sowing Period
P - Purpose
YLD - Yield

SC	SP	P	YLD
0	0	0	0
0	0	0	1
0	0	1	0
-	-	-	-
-	-	-	-
-	-	-	-
1	1	1	1

IF SC=0, SP=0, P=0, YLD=1 THEN Resultant Variety will Be BH 393, BH885, BH902, DWR 28
(where YIELD 40-45)

IV. RESULTS AND DISCUSSIONS

Variety selection module is an important module of the developed system that enables the farmer to select the variety of his choice. The module suggests a variety of farmer's choice for different production conditions and purposes. He can have a variety according to his state, sowing condition, sowing period, purpose, yield etc. As

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farmers, research workers, scientists and consumers select a variety based on different characteristics, the module carries two broad categories; one exclusively for farmers and the other for all other users. The vital characteristics have been identified specifically for the barley growing farmers.

The barley expert system concludes the results by running the knowledge base through inference engine. An **inference engine** is a computer program that tries to derive answers from a knowledge base. Inference engine works on the logical reasoning, inference mechanism and working memory where information is temporarily transferred at the time of decision making

The chaining mechanism used in this system is forward chaining and backward chaining. The barley expert system accepts all facts from the user and reason forward to reach a conclusion. Programme modules are built by using IF-THEN rules, which is part of the inference engines or inference procedures that manipulate and use knowledge base.

Forward chaining is a popular implementation strategy for expert systems, business and production rule systems. Forward chaining starts with the available data and uses inference rules to extract more data (from an end user) until a suitable variety is selected.

Suppose the user wants to select variety for Rajasthan state on the various conditions such as sowing condition, sowing period and purpose.

Backward chaining starts with a list of goals (or a hypothesis) and works backwards from the consequent to the antecedent to see if there is data available that will support any of these consequents. An inference engine using backward chaining would search the inference rules until it finds one which has a consequent (**Then** clause) that matches a desired goal. If the antecedent (**If** clause) of that rule is not known to be true, then it is added to the list of goals (in order for one's goal to be confirmed one must also provide data that confirms this new rule).
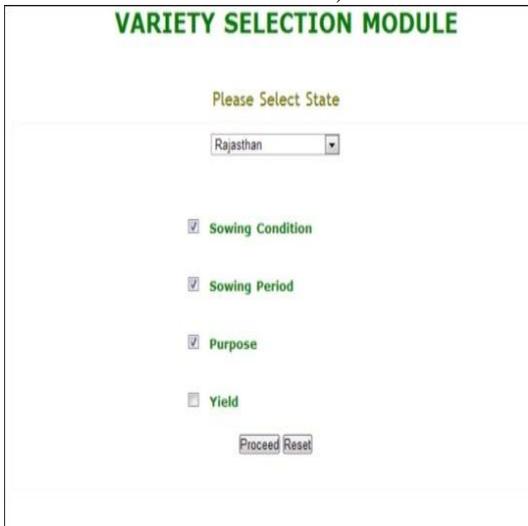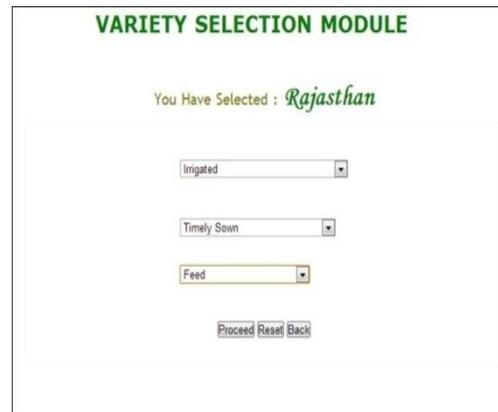

Fig 4: State and Condition Selection

Fig 5: Required Condition Selection

Fig 6: Result Concluded

Barely expert system uses backward chaining mechanism for extracting the information regarding the barley variety being enquired by the user. Basic idea behind using this chaining mechanism is that what if user wants some knowledge about the particular variety.

For example: User needs information about barley variety HB L391 the expert system will run its backward chaining having the goal and searching for the related information stored about the variety that is state, sowing condition, sowing period, purpose, yield, its reasoning will be performed on the data stored and when all of these conditions will satisfy, the particular variety or the resultant information will be displayed by the expert system to the user.

State	Sowing Condition	Sowing Period	Purpose	Yield
Himachal Pradesh	Rainfed	Timely sown	Feed	32.1

Fig 7: Result based on Variety Selected

The expert system can be updated easily to provide the latest information to the end users. Barley expert system is a web-based system with a knowledge base editor that helps the developer and user to easily update (if they are provided with the password) and check the knowledge base.

A farmer can narrow down his needs and may look for a variety that fulfils his requirement for different production conditions and purpose such as feed, dual purpose, grain and malt. It can be done by his selection based on various characteristics. For example, a farmer may look for a variety to grow in Haryana that should give him 4.5–6.0 tonnes/ha of yield. The system shows the variety on the basis of query. The user can get an expert advice on barley varieties on the basis of queries posed. The user will have all the characteristics of a variety while suggesting the name(s) of varieties suitable for the desired production condition.

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