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Decision Support Tools in Potato : A Review of Work Done at ICAR-CPRI

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Abstract

Agriculture today has become a highly knowledge intensive enterprise. Moreover, in the modern day paradigm of sustainable development goals, farmers are expected to produce more from less inputs and with minimum detrimental effect on the environment. The farmer on the other hand desires to get the maximum profit using the resources available at his command without deteriorating his non-renewable resources. This calls for expertise for determining the quantity of various inputs to be used as well as scheduling of various cultural operations. Thus agriculture calls for great deal of managerial and technical skills for successful crop production and its marketing. Information Technology (IT) is the mantra of modern world. Today IT has pervaded each and every field of human endeavor including agriculture. Unlike medicine, engineering and commerce, its application in agriculture is much slower primarily due to paucity of IT trained manpower in this sector. The institute has so far developed many decision support systems, some are Indo-Blightcast, The Potato Pest Manager (PPM), Potato Growing Season Descriptor, Potato growing period and yield calculator, Computer Aided Advisory System for Potato Crop Scheduling (CAASPS), Potato Weed Manager, VarTRAC, etc. An EBook on potato and a potato photographic database are also developed at ICAR-Central Potato Research Institute Shimla. This paper presents a reiew of the Information Technology related Decision Support Tools developed at ICAR-Central Potato Research Institute, Shimla HP and also other IT related activities being conducted there.

Introduction

Agriculture today has become a highly knowledge intensive enterprise. Today, the farmers are expected to produce maximum from less inputs and with minimum detrimental effect on the environment. The farmer on the other hand desires to get the maximum profit using the limited resources available at his command without deteriorating his non-renewable resources. This calls for expertise for determining the quantity of various inputs to be used as well as scheduling of various cultural operations. Thus agriculture calls for great deal of managerial and technical skills for successful crop production and its marketing. Tactical exploitation of Information Technology in agriculture is the key to increasing the sustainability of agriculture and empowering farmers for decision making. This paper presents a reiew of the Information Technology related Decision Support Tools developed at ICAR-Central Potato Research Institute, Shimla HP and the ICAR-All India Coordinated Research Project on Potato.The institute has so far developed many decision support systems, some of these are Indo-Blightcast, The Potato Pest Manager (PPM), Potato Growing Season Descriptor, Potato growing period and yield calculator, Computer Aided Advisory System for Potato Crop Scheduling (CAASPS), Potato Weed Manager, VarTRAC, etc. An EBook on potato and a potato photographic database and a Nutrient recommendation tool for MP, Punjab and UP.

Some of these Decision support systems are:

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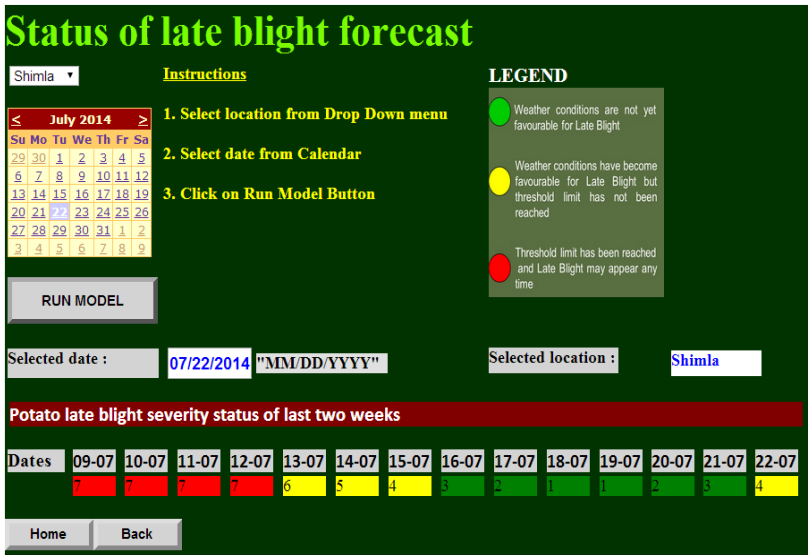
1. INDO-BLIGHTCAST- A web based Pan India Model for forecasting potato late blight

Late blight is the most dreaded disease of potato causing annual crop loss of about 12 billion € globally. Its appearance and spread is highly dependent on environmental factors. Under favourable conditions its spread is so fast that it can wipe out the crop within a weeks' time. In India it is very serious in the hills where it occurs regularly but in the plains it may or may not appear and even if it appears its time of occurrence would vary. The time of its occurrence and severity determines the yield loss which may exceed 40% country wide in some years. Prevention through prophylactic sprays of recommended chemicals is the best option since once it appears it is very difficult to control. This, however, requires information on the likely time of appearance of the disease and hence the importance of disease forecasting.

INDO-BLIGHTCAST- is a web based forecasting model (http://cpri.icar.gov.in) developed to predict the first appearance of late blight disease using daily weather data of meteorological stations. This is an improvement over the JHULSACAST model, which requires hourly data of temperature, relative humidity and daily rainfall. The intensive data requirement as well as location specific calibration of JHULSACAST was a serious impediment to its wide spread use. The INDO-BLIGHTCAST, however, is applicable pan India, since, it is web based, it requires only daily weather and does not need local calibration for different regions. Hence it is more robust and its predictions are broader based.

INDO-BLIGHTCAST has two modules one for data entry and the other for the general users to see the status of late blight forecast.

Data entry: The data entry module is user and password protected. The registered users can "Load data"(for viewing already entered data), "Add data" (to save entered data), "Edit data" (to change entered data values) and "Delete data" (to remove data) if required, in addition to running the model. Check late blight appearance status: Through this button, any user (requires no registration) can select any location which would lead to another window with a calendar and map showing the location with default state map. The user can select a date in the calendar and click on the "Run model" button which would then display the status of late blight in a circle through colour. Green colour indicates that late blight is not likely to appear soon; yellow colour indicates that late blight would appear very soon; and red colour indicates that the weather conditions have become suitable for late blight and it can appear any time within fifteen days. Thus depending upon the time required for taking control m easures, the user may start preventive measures at yellow or red colour indication. The model has been developed and tested using the data on late blight appearance monitored at ICAR-CPRI regional stations and AICRP centres over the past several years.



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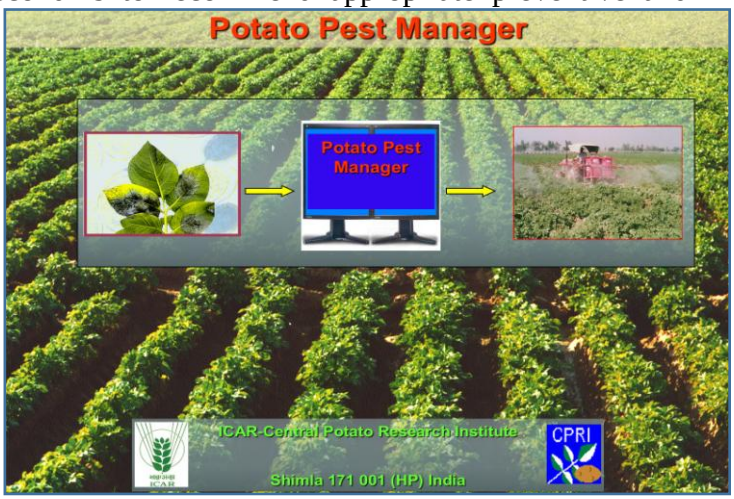
2. Potato Pest Manager (PPM)

For the management of diseases and pests two aspects are involved. The first is to establish the identity of the disease/pest and second is to recommend appropriate preventive and management practices to control them. These objectives are achieved in a sequence of steps as discussed below



Step 1: The photographs showing the symptoms of the diseases/pests are arranged in a photo gallery and displayed in sequence. The user is asked to match the symptoms in the photographs with those he has seen in the field and select the most closely matching one.

Step 2: The appropriateness of the selected photograph needs to be confirmed, because the user may not be fully conversant with the symptoms of different diseases or damage by pests. Information about the biotic/a biotic factors prevailing, together with the symptoms, are necessary for a correct diagnosis. This is done through a set of confirmatory questions.

These are questions about the symptoms of the disease/damage by the pest, or conditions which need to be satisfied for the disease/pest occurrence. This information is arranged in a linear fashion. This arrangement allows insertion/deletion of questions/an option to a question at any level without disturbing the overall structure. Furthermore, this information is presented in a format of questions/statements to the user, while answers are given as options to these questions/statements.

Step 3: Once all the confirmatory questions are answered, the name of the disease/pest corresponding to the photograph selected is displayed along with confidence percentage. The confidence percentage is calculated based on answers given to the confirmatory questions relevant to disease symptoms/pest damage. Each confirmatory question/statement is assigned a certain value such that for all the questions if the option corroborating the disease/pest whose photograph is selected is chosen as the answer, the value adds up to 100.
However, the value allotted to each question may vary depending upon its significance.

Step 4: Many potato diseases/pests can only be controlled through preventive measures taken over a period of time before planting the crop and control is not possible once the disease/pest appears. This is especially the case with diseases/pests where symptoms are seen at/after harvest. Therefore, the preventive measure applicable to the disease/pest identified is displayed in this step. The preventive measures are the set of practices, which would have prevented/mitigated the disease/pest occurrence.

Step 5: In this step information required for suggesting control measures on the standing crop is obtained through a further series of questions. For example, information regarding severity of disease/pest damage, age of the crop, *etc*. is invariably required for deciding the chemicals to be used, their dosage, number of sprays *etc*. This information is again obtained from the user by presenting the questions or statements with various options. The questions or statements are arranged in tree structure and depending upon the answers given to each question a path is followed leading to a recommendation which is attached at the end node.

Step 6: This step displays the recommendation based on the options chosen.

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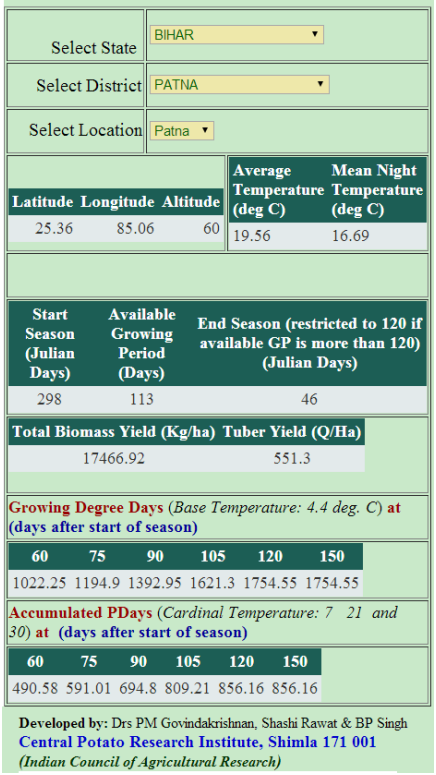
This tool/DSS is web based and is developed in ASP.NET and the database is developed in Microsoft SQL. It can be accessed from ICAR-CPRI website (http://cpri.icar.gov.in).

3. Potato Growing Season Descriptor (PGSD)

Potato is one of the most sensitive crops to the environment. It has specific temperature and photoperiod requirements for growth and development. Apart from the phenology and growth and yield, the weather conditions during the growing season also affect the size of the tubers as well as its quality. There is also a wide variation in the pest and disease scenario affecting potato primarily due to differences in the in growing season environmental factors in different locations/seasons in which potato is grown in India. Moreover, potato has been adapted to be grown under subtropical conditions in India. This has been possible by the development of resource intensive production technologies. Therefore there is need for careful planning of the production strategy by analyzing the growing season.



The PGSD consists of a database of daily meteorological data generated by MARKSIM weather generator for many locations. The daily meteorological data is analyzed using algorithms to determine the length of the plausible growing season, mean daily temperature, mean night temperature, accumulated growing degree days and accumulated P days during the autumn growing season. The tool also gives the expected yield calculated using a summary model of the autumn crop under constraint free situation. It is expected that these information would be useful for production managers, extension workers and farmers in planning their production strategy. It can be accessed from ICAR-CPRI website (http://cpri.icar.gov.in).

4. Potato Growing Period & Yield Calculator

Potato is a short duration crop grown under diverse growing conditions. It is highly flexible in terms of time of planting as it can be planted early, at optimum time or late in the season. Similarly, as regards harvest time it can be harvested at any time after about 3 quarters of the growing season by which time economic yields are realized. Such flexibility makes it an ideal choice to fit in multiple cropping systems. To exploit this flexibility at any given location there is need to identify the growing season/s and the length of each growing season/s. Temperature is the primary determinant for potato under sub-tropical conditions of India. The temperature suitability criteria are that the maximum temperature should be less than 35 ºC, minimum temperature should be less than 21 ºC at least 3 weeks after the maximum temperature suitability criteria is met and it should also be more than 2 ºC to ensure frost free season. Identifying the suitable growing period based on these criteria is difficult and there is also a need to know the expected yield in the different season. A PC based tool was developed for delineating the potato growing seasons and the expected yield of any given season for any location as given in the flow chart below.

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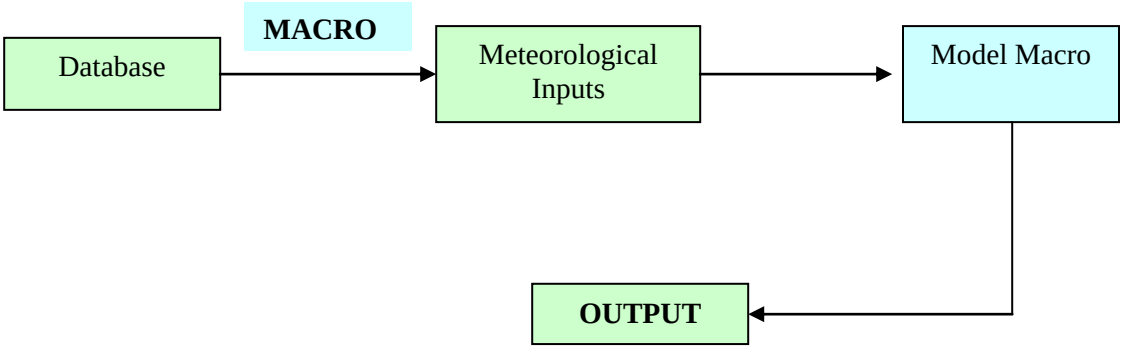


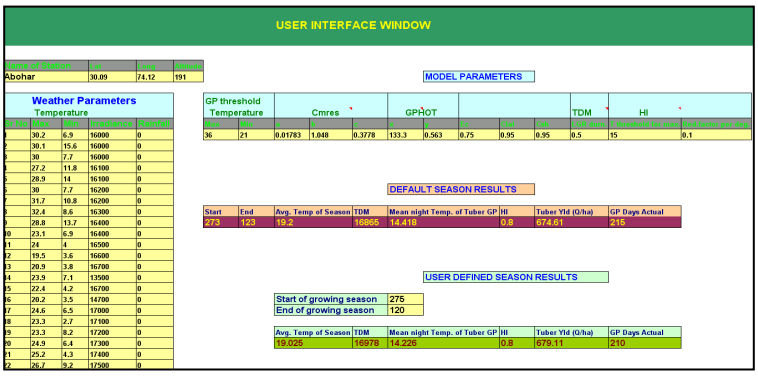
A spreadsheet with macros was created to process the raw data and extract the information required by the model. Four fields each with 365 records were created in spreadsheet and macros for screening the day as suitable or unsuitable for potato based on threshold limits for maximum and minimum temperature was written. The starting day number, ending day number and the total number of suitable days of the longest period, where more than two growing seasons were obtained, were derived as outputs. Further the meteorological variables required by the model *viz*. mean temperature and mean irradiance of the growing season were derived from the data of the thermally suitable days for potato.

Macros for estimation of gross photosynthesis (GPHOT), maintenance respiration, linear growth rate *etc*. (Versteeg & vanKeulen, 1986) utilizing the outputs of the database screening macros were written to derive the expected potential yield.

A Graphical User Interface (GUI) was designed in MS Access/Visual Basic. Fields were created for display of location and its spatial features and also for display of the various outputs as shown below.

5. Computer Aided Advisory Syatem for Potato Crop Scheduling (CAASPS)

The optimum time of planting, the most suitable variety and the expected yield at different dates of harvest are vital information required by farmers for scheduling their planting and harvesting times as well as for choosing the variety to be grown.



Obtaining such information through field experimentation in the diverse agro-climatic conditions in which potato is grown in India is an uphill task, but this information can be derived from crop models which can simulate crop growth, development and yield with reasonable accuracy under diverse situations.

However, use of crop models requires extensive data inputs as well as technical expertise to handle the model. Therefore, world over, models are handled by researchers and off take of models by field level workers is not very satisfactory. Decision Support Systems (DSS) on the other hand provide a method for delivery of information in a user friendly and simple way. Therefore, this DSS "Computer Aided Advisory System for Potato Crop Scheduling (CAASPS)" has been developed with the following purposes:

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a) To provide information on the expected yields of different varieties planted at different times to enable farmers to decide on the most suitable one for their respective locations.

b) To help decide the time of harvest based on yield accrued at 60, 70, 80 and 90 days after planting.

c) To indicate the varietal performance under different dates of planting and crop durations and thus help choose the appropriate variety.

This DSS consists of a database and a user interface. The database consists of state, district and location names along with Info crop-potato model derived yield outputs.

The model outputs were derived as follows:

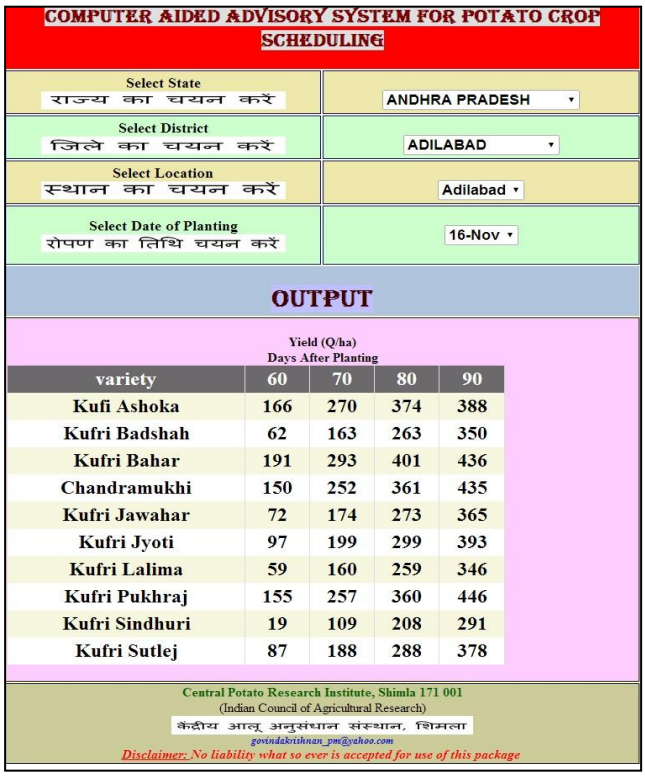
1) Weather database were created for important locations in India using MARKSIM weather generator.

2) Suitable thermal window were delineated for each location by defining screening rules for maximum temperature (< 35^0C) and minimum temperature (< 21^0C).

3) Infocrop-potato model was run for 5 planting situations starting from ten days earlier to the beginning of the suitable thermal window identified by the screening rules and staggered at 10 days interval.

4) For each date of planting, the model was run for 10 varieties under potential situations and 80% of the potential yield was taken as attainable yield.

5) Yield output of each variety at 60,70,80 and 90 days after planting were linked to corresponding spatial attributes *viz.* state, district and location names in MS Access.



User interface: A simple query system was designed for querying the database.

The user first selects the State, and then the Districts of the state. The locations within the district for which information is available are then displayed for selection of one of them.

Once the location is selected, the five dates of planting for which model has been run for the selected location is displayed and the user is required to select one of them.

When any of the dates is selected, the attainable yield data for all the ten varieties at five durations, corresponding to 60, 70, 80 and 90 days after start is displayed in tabular format.

This tool/DSS is web based and is developed in ASP.NET and the database is developed in Microsoft SQL. It can be accessed from ICAR-CPRI website (http://cpri.icar.gov.in).

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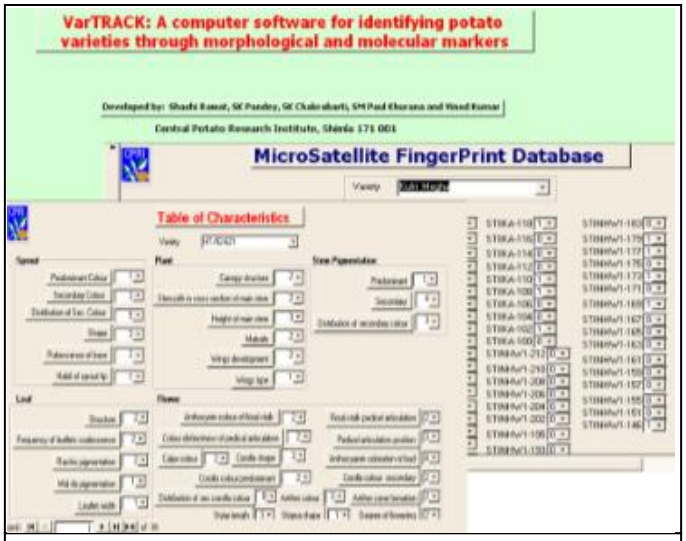
6. **Potato Weed Manager (PWM):** Weeds cause enormous loss in potato production. Weeds in potato not only compete for moisture, nutrients, space and light but also harbour several pests and diseases as alternate hosts. Up to 80% reduction in the productivity of potatoes due to weeds is reported. A number of cultural, mechanical as well as chemicals methods are available for controlling weeds in potato crop. Herbicides are available for control of different types of weeds at different stages. The selection of proper herbicide depends upon the type of weed flora and the stage of crop growth. However, weeds prevalent in potato crop vary from region to region and season to season and in the absence ofknowledge about weed flora, it is difficult to give precise recommendation for their control. The knowledge of farmer about the weeds is limited only up to its local name and the extent of damage it may cause. Moreover, availability of proper guidance about weed control in the absence of technical advice may lead to improper control method leading to inefficient weed control. To alleviate this problem, a decision support tool "Potato Weed Manager" has been developed. The software is developed in DOT NET technology and the database used is SQL. This software is hosted on CPRI application server and is connected to CPRI website. This software incorporates the photographs of the weeds for identification by the user. This software gives the recommendation for weed control on the basis of situation of potato field, type of weed flora (major and secondary/associated weeds) and the stage of the potato crop. Thus the software provide proper guidance to the farmer about the weed control method to be adopted and dispense with the need of technical knowledge. It can be accessed from ICAR-CPRI website (http://cpri.icar.gov.in).

7. VarTRAC: Bioinformatics Tool for Identifying potato Varieties



A combined view of different windows of the "Var TRAC"

Authentic identification of potato cultivars is important for plant breeders, the variety registration and certification agencies, seed producers, merchants, farmers, growers, processors, and other end-users. Currently morphological descriptors are being used internationally for variety identification. However, there is a possibility of utilizing DNA fingerprint data to supplement morphological characters in near future. Central Potato Research Institute, Shimla is, therefore, developing both morphological and DNA fingerprint databases for potato cultivars' identification.

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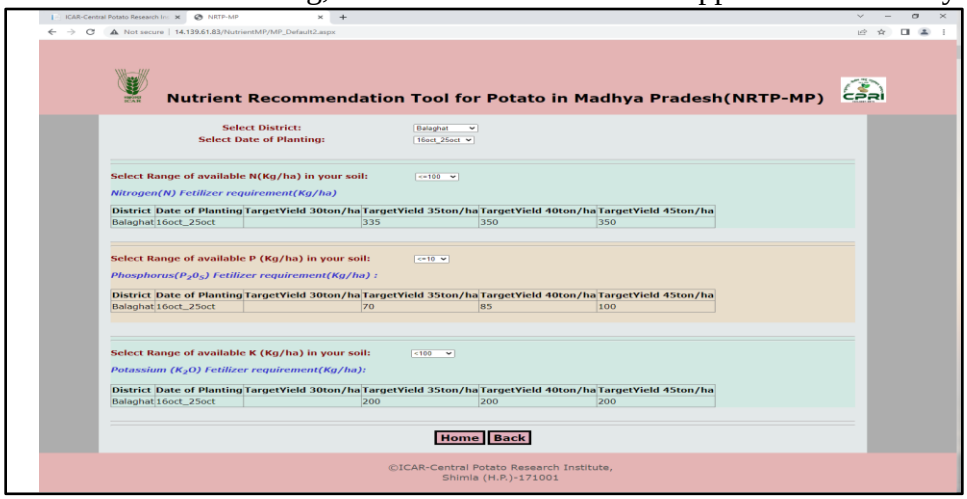
Data on 50 different morphological attributes and DNA fingerprints based on 127 alleles from 4 micro-satellite markers are currently being used at CPRI for varietal identification. Manual analysis of such huge data is not easy. Therefore, a computer software named "Var TRAC" was developed at CPRI for speedy identification of a variety based on the morphological and DNA fingerprint data.

The database was created in MS Access with each morphological character taken as a field. All the characters necessary for the identification of a potato variety have been included. Scores are given for each character in a drop-down menu format and the users have only to select the appropriate score for each character. Further the help has also been provided for proper scoring. As regards DNA fingerprints, the data on 127 alleles have been recorded by giving a score of one for those alleles, which are present while zero for the absent ones.

The software can make generalized abstraction even from the minimum available information. For example, if only 5 morphological attributes of any unknown variety are known, the software can identify the group of varieties having similarity in respect of those 5 attributes.

8. Nutrient recommendation tool for MP, Punjab and UP

Application of fertilizers is a major component in total production cost of any crop including of potato where the efficiency of applied nutrients is quite low as compare to several other field crops. The under application as well as the over application of fertilizers, both are undesirable as on one hand the under application results into lesser yield of the crop resulting in low economic return from the farming, on the other hand over application not only increases the cost of cultivation but also poses the severe environmental hazards. Besides, it increases the burden on our already depleted reserves of nutrients. Thus, it is desired that the fertilizers should be applied judiciously and precisely as per the requirement of the crop. Models are the replica of system that can be represented physically or mathematically, QUEFTS model is one of them. QUEFTS model has various concepts of soil fertility built into it. QUEFTS distinguishes itself from other fertiliser recommendation tools by its ability to account for interactions between nutrients. QUEFTS provides diagnostic tool to analyse experimental data and helps in making precise fertilizers recommendations. It is a site-specific nutrient management approach,whichdescribes the quantitative evaluation of the native fertility of tropical soils, using yields and NPK uptake trials. QUEFTS has been calibrated and validated for best fertilizers management of NPK in rice, wheat, maize, cassava, elephant foot yam and sweet potato. ICAR-CPRI have calibrated this model for Potato crop. The decision support system has been developed in ICAR-CPRI on the output derived from QUEFTS Model.



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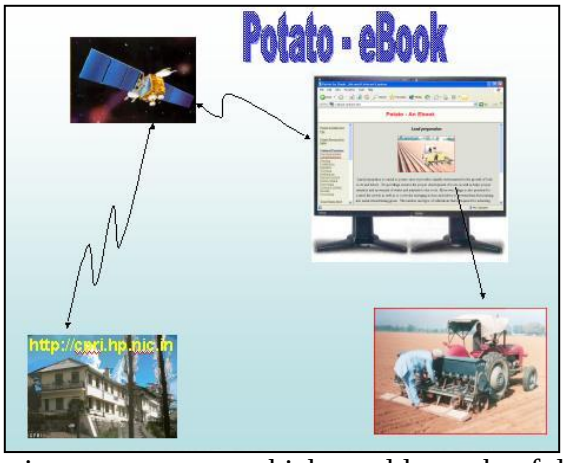
The input is given in the form of date of planting, district and available NPK value of the soil status. The output of the tool is the recommendation of NPK doses for different target yields ranging from 30-tons to 45-tons based on the district selected, date of planting and available nutrients. In case the users do not know the NPK status of their field, they can choose the other option where the tool takes the default value for the particular district and give the recommendations accordingly for the same. The tool is user friendly and helps the farmers to decide the application rate of NPK nutrients for a fixed target yield based on their inputs of planting date, district and soil test values. For making it more user friendly, the values are given in the form of a drop down list from where the user can select the value easily and does not have to type anything.The DSS was developed using ASP.NET (C#) technology and the database for the same has been designed using SQL Server.

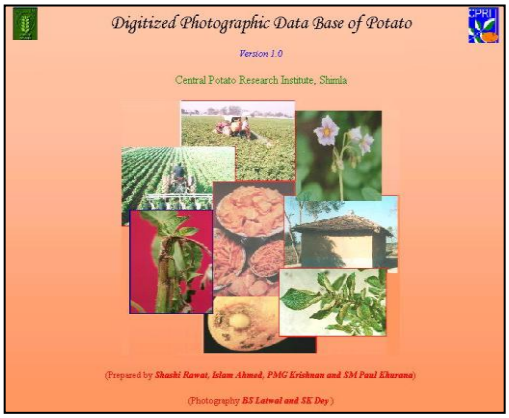
OTHER IT RELATED INITIATIVES

1. E-BOOK ON POTATO



E-book on the Potato is meant to give a bird's eye view of practical knowledge about the potato production, utilization, *etc*. in India. It is aimed at providing appropriate information for all those interested in knowing about the ways potato is cultivated in different regions in India, the reasons for the adoption of the various agro techniques and the major abiotic and biotic stresses. This is expected to provide insights about the scientific cultivation and utilization of potato. This e-book is also meant to be a supplement to many excellent publications on potato, which could not be fully illustrated with photographs due to limitation of cost of printing. This lacuna is overcome in this e-book since cost factors are minimum in this case. Thus, this e-book apart from being used as a book *per se* would also be a pictorial supplement to other publications available in print. Through this e-book, it is hoped to further strengthen the cause of potato R&D in India using the electronic media, the use of which is becoming rampant.It can be accessed from ICAR-CPRI website (http://cpri.icar.gov.in).

2. DIGITIZED PHOTOGRAPHIC DATABASE OF POTATO



The creation of photographic database is a very important activity because information can be presented very easily and concisely through photograph rather than text. Therefore, a digitized photographic database was developed. It can be used by professionals in their presentations, extension lectures to the farmers/industry entrepreneurs, in publication of scientific books, technical bulletin *etc*. The database contains more than 600 photographs pertaining to all aspects of potato research and development. The use of this database does not require any specialized skill.

Conclusion

As agriculture today has become a highly knowledge intensive enterprise and farmers are expected to produce maximum from less inputs and with minimum detrimental effect on the environment, it calls for great deal of managerial and technical skills for successful crop production and its marketing. Tactical exploitation of Information Technology in agriculture is the key to increasing the sustainability of agriculture and empowering farmers for decision making. ICAR-CPRI has made commendable inputs in this direction by developing many Decision Support Tools and other Information |Technology related initiatives have also been undertaken to take the required information related to potato cultivation to the stakeholders.

Note: All the screen shots depicted in this paper have been taken from the CAR-CPRI website (http://cpri.icar.gov.in).