Analysis of Soil Management Data Module of DSSAT Model

Sikander Singh Cheema, Amardeep Singh
Department of Computer Science and Engineering
Punjabi University, Patiala

Abstract
Crop growth simulation models are used to predict crop production for different regions. A few crop simulation models have been formulated worldwide for a wide assortment of harvests which have been adjusted and approved under shifting conditions. These models are being used for surveying and anticipating crop development and yield. Various practical problems can be solved in agriculture using these models. The item models can be used to anticipate alter execution in areas where the yield has not been created beforehand or not created under perfect conditions. Such applications are of motivator for territorial advancement and agrarian arranging in the locales like Punjab. A model can discover probabilities of grain yield levels for a given soil compose in view of previous year's rainfall record. Substantial and consistent traditional agriculture can cause loss of soil natural carbon, and additionally increment soil disintegration and decay of soil structure. Over the most recent couple of years, the scan for hones that enhance soil richness and profitability and horticultural support ability has expanded. Our target of this investigation was to assess the ability of DSSAT (Decision Support System for Agrotechnology Transfer) model to anticipate yield and its parts for various crops of Indian Punjab grown in different types of soil under different weather and irrigation methods. The crop simulation program of DSSAT could be utilized to grow various crops instead of one or two. This program incorporates various modules those are utilized to predict yield depending upon various parameters but in this paper author will discuss only soil module in detail. There are many parameters which are used to predict the production of any crop but soil is a very important parameter from all of them. Various types of soils are available in Indian Punjab, so it is very necessary to check that which type of soil is suitable for a particular type of crop. In this way simulation models are playing a major role to predict the yield of a specific crop by observing various input parameters like soil, weather, rain fall etc. This paper will focus on the soil module of DSSAT model to predict the outcome of any crop depending the soil contents.

Keywords: Crop; Simulation; Productivity; Soil; Punjab; DSSAT.

1. Introduction

The item models can be used to envision alter execution in zones where the reap has not been created beforehand or not created under perfect conditions. Such applications are of motivation for common place headway and cultivating orchestrating in regions like Indian Punjab. A model can figure probabilities of grain yield levels for a given soil compose in view of previous year's yield record. Crop production involves a complex interaction between crop genotype, the soil and the aerial environment, and crop management practices. Information generated about the various components of the production system and their interactions has been used to develop crop simulation models [2]. These models have the potential of taking agricultural research and development into the age of fast information technology.

The cropping models are being developed to meet the requests under the accompanying circumstances in agricultural meteorology:

1. At the point when the farmers have the troublesome endeavor of managing their harvests on poor soils in fierce.
2. When researchers and research supervisors require instruments that can help them in adopting a coordinated strategy to discovering arrangements in the perplexing issue of soil and crop yield [3].
3. When organizers require straightforward apparatuses that can help them in strategy management in agrarian meteorology.

A very much approved and adjusted simulation model can assess different agronomic treatments for their reaction on crop development and yields. Crop simulation models have risen as essential apparatuses to improve yield by analyzing various input parameters. The DSSAT (Decision Support System for Agrotechnology Transfer) model is such a product model which has been utilized generally by analysts most broadly in foreseeing the growth and yield of crops, as a crop management tool. There are various modules in DSSAT model which are used to predict the outcome of a crop, authors are focused on only soil module in this paper. Soil data module in the DSSAT contains various parameters which are used to analyze the production of a crop [1]. Functions of the soil module are analyzed according to the requirements for Indian Punjab.

2. Related work

In soil data module of DSSAT model has various fields which are used to predict yield of a crop. When one will work on soil data module of DSSAT, then one has to create profile according to the contents of that area's soil. Here to create a new soil profile one has to open the profile tab and after filling the values of the various fields under General Information and Surface Information, then go on the next screen. On the second screen it will show the complete profile of the soil. So from this profile one can easily get detailed information of soil's parameters. After analyzing the database of soil and crops, one can predict a suitable crop for that particular type of soil. So in this way under the soil module of the DSSAT model, one can get the information about all the components of the soil. After getting the complete information of the soil, one can get idea to grow a particular crop in that soil. Every crop requires specific soil to get good production. From the next two screens one can get the knowledge of the various fields related to the soil.

In the below shown figure one will enter the values of all the required fields related to the soil to get the new profile.

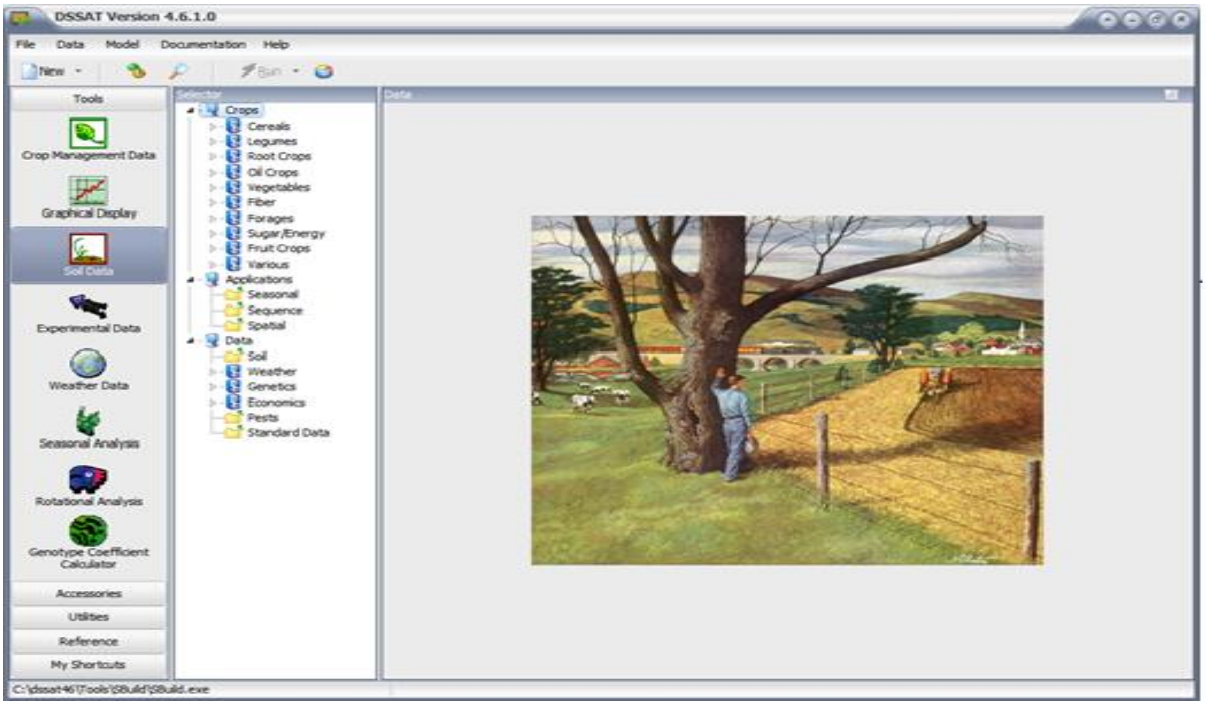

Figure 1: DSSAT

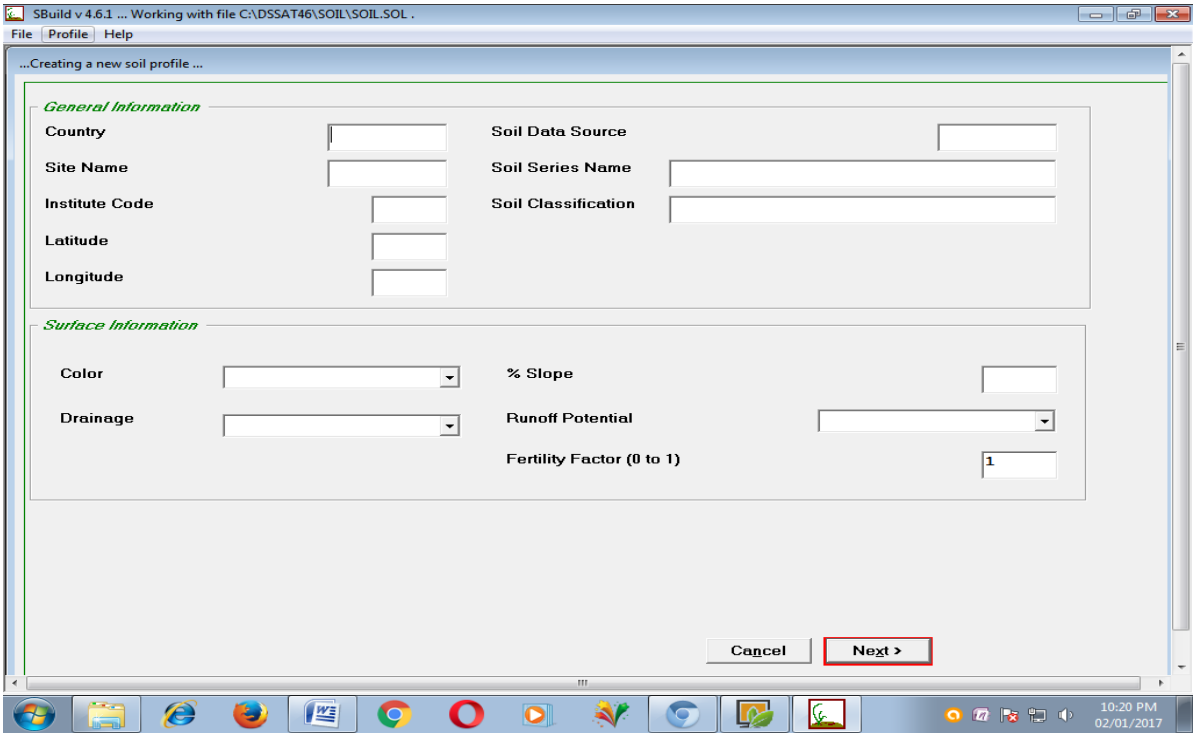

Figure 2: Soil Profile

After entering the values of all the fields, the new profile will be created as shown in the below screen.

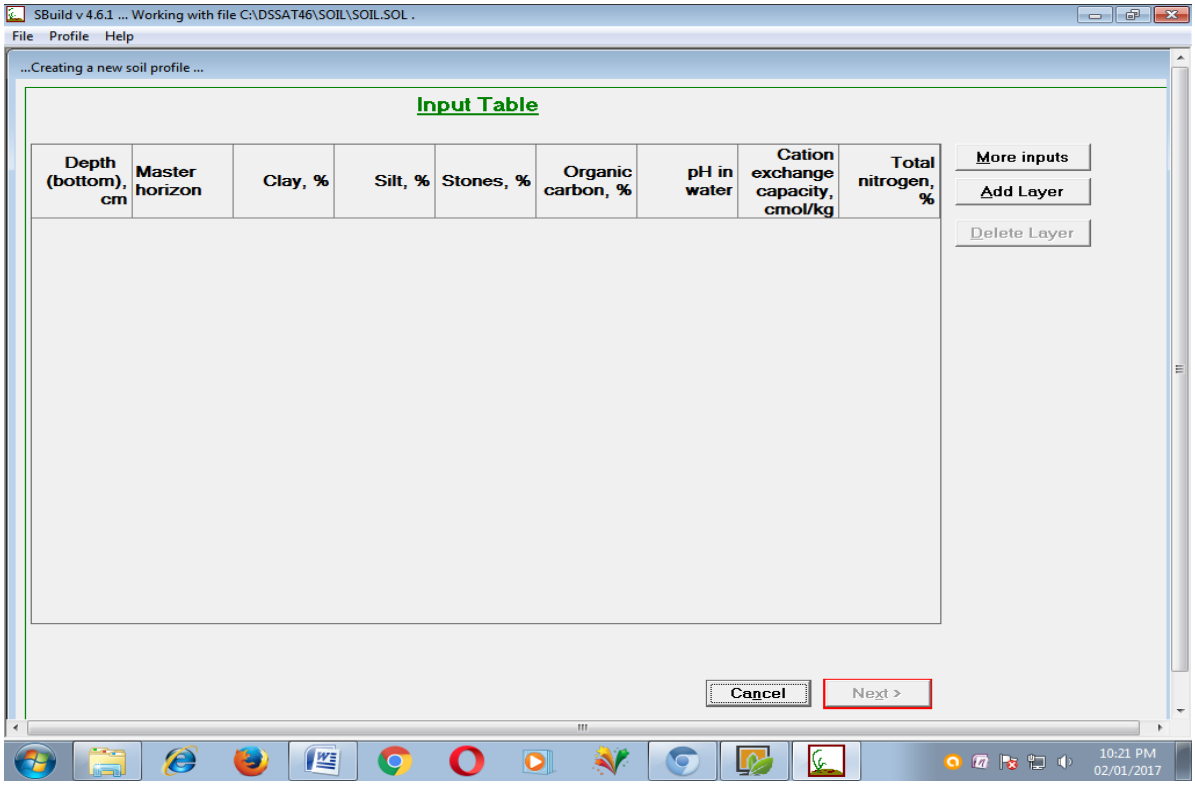

Figure 3: Input Tables

After getting the new profile then one can compare all the required fields of the soil parameters with the parameters present in the crop-soil database. From that database one can select the required crop suitable for that particular type of soil.

Soil module has four sub-modules: soil water, soil temperature, soil carbon and nitrogen, soil dynamics. These sub-modules are helpful to analyze the different angles of soil. For example soil water sub module analyses the day to day variations in soil water which are occurs due to rainfall and irrigation, soil evaporation, and root water uptake practices. The soil has various contents that give overview about the soil surface situations, soil water holding capacity layer wise layer etc. Soil temperature sub-module helps to compute soil temperature from air temperature and a deep soil temperature boundary condition. This module is used to compute the impact of solar radiations on soil. This module is also used to change plant process and soil organic decomposition. Soil carbon and nitrogen sub-module describes the soil organic matters in the soil which helps to improve fertility of soil [1].

DSSAT is an expert simulation system based on a modular structure. In an Expert System, a complete information about a system is acquired from an expert then a software engineer/ developer will try to digitize the whole information/data collected from an expert of that field.

Whatever the rule and regulations will be set by an expert/developer, the system will act accordingly to take the decisions. Based upon the feedback of users/experts new rules/regulations will be injected by the developers into the system. In this way one can improve an expert system time to time depending on the requirements. DSSAT model is also working as an expert system and it is flexible also, depending upon the requirements of the users, experts/developers can add more modules. Now a days more flexible system are coming into market which are working on machine learning concept. Both (Expert system and Machine Learning) are sub-fields of artificial intelligence. Basically machine learning is based on statistical modeling of data which projects the input into some model space. In other words one can say, Machine learning can be seen as a mechanism that helps the system to make decisions and induces the knowledge into the system. Data plays an important role in both systems but in machine learning, system takes more decisions independent of human based on the historical data, e.g. Weather Data prediction based on historical data etc. Depending on the applications, one can use expert systems or machine learning. If there are a large number of unknown options or has a significant amount of variance, a machine learning approach is the best and provides the leading amount of exposure [10]. On the other hand if one deals with less unknown options or has a small set of known options with low variance, go with an expert system approach.

To design such expert system, one should try to understand the analysis process of data available from many resources. Now a days it is a big task to analyze the data to retrieve an important information. In all fields, data is available in large amount but main task is how to get information from that data. One such example is mining educational data from available resources [9]. To design the training data sets one can use such data mining techniques which can help to design such models at education level. There are many applications of expert system (like DSSAT) and machine learning. In next paragraph, author will discuss more applications of expert system and machine learnings.

Applications of Expert Systems and Machine Learning

Artificial intelligence techniques help to improve crop production, protection of crops from diseases using the real time data. As population in increasing day by day, there will be a big demand of food in future, so to fulfill this demand expert systems and machine learning techniques will play a major role. There are many applications of expert system and ML, explained as below:

1. Analysis of bank's stock data to find out the various findings like values of shares for past many years, performance of the bank, customer satisfaction (data collected from various social medias) etc. By using machine learning techniques, one can study the data (collected from bank's databases and social medias) which is available in bulk and can give predictions to take decisions in the future [11].
2. Artificial Intelligence techniques (machine learning) can be used to increase the yield of crops by analyzing the real time sensor data and visual analytics data from drones. Using this data one can analyze the growth of a crop by observing the moisture, fertility level, and natural nutrients level with respect to time. So based on such data, suitable decisions can be taken to improve the yield of a crop. In this way machine learning is a good technique to get a required data to take such decisions in the future [12].

3. Many international agencies working in the field of agriculture are pioneering drone data combined with in ground sensors to improve pest management. By getting infrared camera data from drones pooled with sensors on farms that can check plants' relative health stages, so any pest infection can be detected by using artificial intelligence techniques by experts before occurring [12].
4. A lot of money can be saved by getting the accurate data regarding the demand of a final product of a crop, so according to that, particular crop can be produced and farmers can get good price of their product as well. Collection of this type of data is possible by using the machine learning techniques [12].
5. Artificial intelligence techniques play an important role to improve the irrigation system and save the ground water: Ground water is very important natural resource but in Indian Punjab the level of ground water is going down day by day, this is an alarming situation for that region. Ground water should be used in such a way that yield of a crop should be high with less usage of water. Supervised machine learning algorithms can be used for ensuring fields and crops get adequate water to enhance yields without wasting any in the practice [12].
6. By using expert systems one can predict the yield of a crop by using the inputs of soil, temperature, moisture etc. In this way to fulfill the increasing demand of food, managements can make the future plans. Yield of a crop can be increased by selecting a suitable crop for particular type of soil using expert system. When a farmers will grow a crop in a suitable soil then variable cost (cost incurred on fertilizers, pesticides etc.) will be less and farmer can earn good money.

3. Materials and Methods

Table 1 contains the information of soil's physical property corresponding the crops.

Table 1

Sr. No.	Crops	Texture
1	Wheat	Clay loam or loam structure. Clay and sandy loam soils also used
2	Cotton	Sandy loam.
3	Rice	clay and sandy loam
4	Corn	Sandy loams
5	Barley	Sandy to loam soils.

In table 1 we have mentioned the few crops, depending upon the requirement, one can increase the number of crops. Texture is a main parameter which is going to decide the type of soil, according to the type of soil, a suitable crop will be selected by a farmer to get high yield.

Table 2 shows the required depth for different types of crops.

Table 2

Sr. No.	Crops	Planting Depth
1	Wheat	1 inch [4]
2	Cotton	0.5-1 inch
3	Rice	2-5cm [5]
4	Corn	1.5-2inches [6]
5	Barley	50-75mm [7]

By creating new profile of the soil's parameters, one can use that created profile for the selecting a suitable crop. That profile of the soil is compared with the physical property (Table 1) of the soil and then by using the required formula one can select the required suitable crop for that soil.

Suitable crop = Maximum (fitness value)

Fitness value = Sum (All the suitable parameters of soil)

Calculated fitness value is used to decide the crop for a particular type of soil. Further fitness value depends on the parameters of soil.

3.1 Input and output requirements

Farming areas can be considered as a collecting of individual fields that shift in natural conditions and administration practices. As population is increasing day by day so requirement of food is also increasing. To fulfill the demands, more resources are required but resources are limited in all the areas. To handle such situation, proper management should be there to manage the things with available resources. In agricultural system, required food can be produced with available resources only as it is not possible to increase the cultivating land particularly in Indian Punjab where 90% land is already under cultivation. So solution is only to do proper management with existing land. For this soil should make enough fertile so that it can produce more with less inputs [8]. Moreover, the focal point of rural generation is changing from amount towards quality and support ability. Arrangement of these new difficulties require thought of how various segments interface to impact plant development. These changes compel farmers and agricultural experts to manage expanding main part of data. They have to investigate tremendous data assets. The data gathering process is bulky. As Information Technology has opened up new difficulties to robotize information and examination, computer programs that restructure the crop development or yield of products under various administration processes enable agriculturists to settle on specialized choices to deal with their yields better. So in this way such models are widely used to check the effect of soil on the crop production and can be used to increase yields with less inputs. For this one has to maintain few files for handling input and outputs. Need of these files is to keep record of crops and soil for further use in future.

Input files : The input data files required for running the model pertain to soil and experiment details. First file required to store the created profile data and other one to store properties of the

soil. In addition to these files, the experiment performance file is also used as input. To run the model, a file containing data about all the accessible tests is given to the model.

Output files: The model run produces output file. The output file, provides a required crop depending upon the soil inputs. The second output file, summary, provides a brief detail of output of all the crops those can be considered for that soil depending upon the soil's properties.

4. Results

A software model developed to facilitate determination of the crop for a particular type of soil. DSSAT model has various modules which are used for the analysis of soil, temperature, weather etc. for the high production of a crop. A new profile is required to be generated to analyze the soil for high yield of a crop using this model. Once the profile data is created then that can help to analyze the result. After doing the mapping, one is able to find out a particular crop or a sequence of the crops in the descending order of their production. Data shown in the tables 1 and 2 is related to the soil and crops, this can be increased corresponding to crops depending upon the requirement.

Table 3. Experiment Performance File

Type of information	**Detailed information**
Field Detail	All available crops
Soil information	Corresponding suitable crop

Table 4: Types of Soil

Sr. No.	Numbers	Soil Types (Texture)
1	1	Clay loam or loam structure. Clay and sandy loam
2	2	Clay and sandy loam
3	3	Sandy loams
4	4	Sandy soils
5	5	Sandy loam, sandy clay loams and silt loams
6	6	Clayey soil
7	7	Sandy to loam soils
8	8	Loamy soils

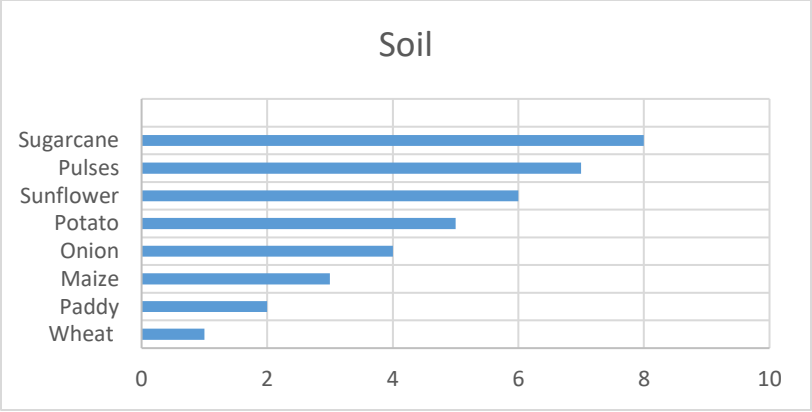

Figure 4: Crop-Soil Mapping

Using DSSAT model, one can create soil profile and a list of suitable crops will be output according to the given soil parameters as inputs. Then farmers can select the most appropriate crop for their fields to get high yield as shown in the Figure 4. Such models can be developed to operate at local levels also.

4.1 Significance of study

Model similar to DSSAT can be designed for local Indian Punjab to select a suitable crop for a particular type of soil and that model will be more beneficial to the local farmers to get high yield. If a soil will be suitable for a crop then variable cost (cost incurred on fertilizers to get high yield) will be less and in this way farmers can earn more money. Moreover by using the developed model, farmers can go for different crops rather than focusing only on one or two. In this scenario, concept of crop diversification can be implemented that is good to maintain the fertility of soil as well as to save ground water. So study of DSSAT model be very beneficial from crop diversification point as well as to get high yield from crops.

5. Conclusion

By using DSSAT model one can evaluate to simulate crop selection, development and yield in the state of Punjab, India. This will help for selection of various suitable crops depending on the properties of the soil. The model is observed to have the capacity to foresee the event of the crop fairly well, this would enable farmers to take decisions on the crop management operations that can be directly linked to cropping process. The conventional research method of transferring new technologies from one place to another takes time and money. As the DSSAT model will help to design new more models and those can be used to get more information related to crops and crop yields. The model developed is envisaged to help the agro technology transfer in the state of Punjab faster by reducing the time and cost otherwise involved. Another finding of the study is that, even though the state receives good rainfall during the summer season but paddy crop need water in large quantity, so by using this model one can predict the alternate crop instead of paddy. This will save the ground water and maintain fertility of the soil.

Challenges for Implementation

It will be very useful the usage of DSSAT model or any other developed model for Indian Punjab to select a suitable crop for a particular type of soil to get high yield, but it will be very difficult to implement the end results of model like crop diversification because farmers will not go easily for other crops than paddy or wheat because good marketing and minimum support price is not available for other crop (in Punjab, Government is procuring only wheat and paddy on minimum support price). But if farmers will not go for other crops than wheat-paddy then fertility of soil as well as ground water (paddy required water in a very large quantity) will be in a dangerous zone. So for the implementation of this study a lot of awareness should require for farmers, and government should also think for procurement of other crops (as in case of wheat and paddy) by giving minimum support price so that farmers can grow others crops to maintain soil fertility and to save ground water for the betterment of environment.

Challenges of this study point towards the issues to be addressed in future. The following are a few areas for future study.

- One should work to convey the framers, the importance of fertility of soil so that they can implement crop diversification concept easily to maintain it. It is need of hour.
- What will be the future of agriculture system without ground water, more study should do in this field and should show the mirror to governments and farmers so that they should think alternative ways to protect ground water and other natural resources.

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