1. Introduction
The information needs of agricultural research data are growing day by day and there is a need to develop information system for meeting research demands and making this available online for use of planners, research managers and researchers under National Agricultural Research System (NARS). In the last few decades the country has made impressive progress in food production which is one of the most vital sectors of Indian economy. This has been possible due to research undertaken by different ICAR Institutes, National Research Centers, Project Directorates and SAUs.

The development of Web based National Information System on Long Term Fertilizer Experiment (NISLTFE) from the data generated alongwith other ancillary and site specific weather information, agro- ecosystem wise will be of immense value to planners, policy makers, researchers and development agencies etc. This information system would also provide a common platform for studying /understanding the complex interactions involving soils, plants, climate and management practices and their effect on crop productivity. The preparation of NISLTFE assumes more importance and usefulness in the era of Information Technology for establishing networking between ICAR Institutes and SAUs with IASRI as a nodal point under a computer network.

2. Long Term Fertilizer Experiments
2.1 Need of Long-Term Fertilizer Experiments
In agricultural experiments, there are reasons to believe that fertilizer treatments once applied on an experimental unit on a crop may not fully react during the crop season on that particular unit. The treatments may leave residual effect on the succeeding crop. For example, very often nitrogen shows a fair response on a crop during the season it is applied. However, due to the increase in plant growth accelerated by repeated application of nitrogen, response to phosphorus and potash becomes, generally visible in the second and third year of experimentation. To formulate fertilizer recommendations for crops, it is, therefore, essential that the experiment should be repeated over time at the same site as the effects of climate, soil, fertilizer, agronomic practices, etc. get stabilized only after a period of years and responses to fertilizer treatments also become more stable and reliable. Long term field experiments, therefore, form one of the most useful tools for technical advances and are indispensable for framing empirical rules for the conduct of practical agriculture. These experiments can be used for precise monitoring of changes in soil fertility and productivity.
2.2 Definition and Types of Long Term Experiments

Long Term Experiments are those, which are conducted on the same set of experimental units over a sequence of years with pre-planned sequence of treatments or crops or both and are mainly carried out to study the long term effects of given treatments and crops on soil fertility and on economic returns. These may be with seasonal crops, annual crop sequences, perennial crops or a combination of the three. Long term fertilizer experiments, long term rotational experiments etc. fall under the category of long term experiments with seasonal crops or annual crops sequence. These experiments include fertilizer experiments with cereal crops, irrigation experiments, tillage experiments, fertility status of soil, experiments on biomass production of cereals, experiments on crop rotation, effects of green manure etc. These experiments provide the effect of continuous application of treatments over the soil productivity and fertility.

2.3 Historical Background

The earliest long-term experiments called Permanent Manurial Experiments were started at Rothamsted Experimental Station, Harpenden, Herts, England between 1843 and 1856 by J.B. Lawes and J.H. Gilbert and are known as ‘Rothamsted Classical Experiments’. These experiments were neither replicated nor randomized. Their main objective was to measure the effects on crop yields of inorganic compounds containing nitrogen (N), phosphorus (P), potassium (K), sodium (Na) and magnesium (Mg) elements known to occur in considerable amounts in crops and farm yard manure but whose separate actions as plant foods had not been studied systematically. The effects of these inorganic fertilizers alone in various combinations were compared with those of FYM and rape cake in most of the experiments. These experiments have been continuing for more than 150 years and have yielded most valuable information for adoption of an efficient approach for managing the crops and cropping system. From 1957, several of the classical experiments were modified to evaluate the residual effects of the annually repeated dressings of different combinations of nutrients.

2.4 Indian Prospective

Based on the Rothamsted model many such experiments were started in several parts of the world. In the beginning of the 20th Century, a series of long-term fertilizer experiments were also established at different locations in India. These locations were at Kanpur (Uttar Pradesh), Pusa (Bihar), and Coimbatore (Tamil Nadu) and started in 1885, 1908 and 1909 respectively. A new permanent manurial experiment was laid out at Pusa (Bihar) in 1935. This was followed by more long-term fertilizer experiments on crops such as sugarcane at Shahjahanpur (Uttar Pradesh) 1935; Padegaon (Maharashtra) 1939; Indore (Madhya Pradesh) 1947; Muzaffarnagar (Uttar Pradesh) 1949; and at Anaka Palle (Andhra Pradesh) 1950 and on cereal based cropping system at Ranchi (Jharkhand) 1956. The principal aim of these experiments was to evaluate the long-term effect of inorganic and organic manuring on crop production and soil health. All these experiments were planned for monoculture and with traditionally low yielding varieties of crops. Unfortunately, some of these experiments were either discontinued or seriously altered as they were found inadequate in respect of statistical requirements pertaining to design of experiments or suffered from some management problems. However, the trials at Coimbatore and Ranchi are still being continued.
3. National Information System on Long Term Fertilizer Experiments
A large number of long term fertilizer experiments on various food, horticulture and commercial crops are being conducted at different ICAR Institutes and various SAUs. Usually the information generated from these experiments is not available in compatible form at one place to the scientific community working in NARS. Planners/ Research workers may be interested in this information because this will help them in the planning/conducting the future long term experiments. Moreover, this information will also be helpful in carrying out the mid-course modifications, without affecting the long-term continuity and integrity of the on-going experiments for studying the new emerging research problems therein.

Keeping this in view National Information System on Long Term Fertilizer Experiments (NISLTFE) was created with the following objectives:

(i) To collect, collate and compile the data on long term fertilizer experiments
(ii) To design and develop a database for long term fertilizer experiments
(iii) To develop a user-friendly web-based information system on long-term fertilizer experiments.
(iv) To evolve suitable mechanism for maintenance, inflow and updating of the information system.

3.1 Source of Information and Quantum of Data
The key source of data information for NISLTFE is the data generated under long term fertilizer experiments conducted/ in progress at various organizations under different divisions of ICAR. For this linkages with organizations engaged in LTFE were established to acquire the experimental information available on various aspects of agro technologies since their initiation. About 25 scientists at these locations were nominated as Nodal Officers by their respective Heads of Institutions for supplying the necessary information and data for NISLTFE. So far a maximum number of 59 experiments under NRM followed by 11 and 4 experiments under srop sciences and horticulture divisions have been identified for entering their data under the system. These numbers would go on changing whenever the information from new experiments is received.

3.2 Requirement Analysis
The requirement analysis was done in close association with the visiting soil scientists, information already available and received from LTFE conducting organizations. The hard copy formats in which the data are being received were also reviewed. Thus using all these methods the nature and format of agriculture information to be stored in database was finalized. Keeping in view the available information the database structure was developed using RDBMS principles.

4. System Architecture and Database Design
The information system has been designed as user friendly and can be used by individuals having no knowledge of computer based information systems or any of the computer software. It has been developed as a web based information system on long term fertilizer experiments conducted in India. The overall purpose of the system is to store, maintain and retrieve the information online.
4.1 Features of the System

4.1.1 Data sharing
The system has been designed to form a centralized database in which the data can be entered /updated through online forms from many internet nodes at the same time. These data can also be retrieved online using variety of reports available on several aspects of NISLTFE. These wide categories of reports can also be shared by different types of users.

4.1.2 Reduction of redundancy and inconsistency
For easiness of data entry, separate database tables have been created. It has been ensured that except for primary keys and foreign key no field appears in more than one database table. This is taken care of by the aspect of redundancy i.e. minimized amount of information needed to solve a particular problem. These database tables have been created keeping in mind the way in which data are to be entered, the types of reports to be generated and queries to be answered online. Efforts have been made in particular to optimize the number of tables, to accommodate all long term fertilizer experiments of crop sciences, horticulture and natural resource management divisions of ICAR, which are required to generate individual reports and answer specific queries. This structure also helps in removing inconsistencies of information stored in data banks.

4.1.3 Adaptability to future requirements
The NISLTFE has been designed as an adaptable system to accommodate any future long term experiment as well as any mid-course modification/ changes within the ongoing experiment, establishment of new organization etc in the developed software system.

4.2 Architecture of NISLTFE
NISLTFE has been developed as a web-based application using JAVA technology. Therefore, it is a platform independent and can be connected from any computer connected to the Internet. The user only has to confirm that computer has a Web-browser. It has three layered architecture as shown in Fig. 1.

Fig. 4.1: Architecture of NISLTFE
The purpose of making the system with three-layer architecture is to provide independence to all layers so that it functions smoothly. All the layers in this architecture are made using appropriate technology and provide enough space to upgrade a particular layer without disturbing underlying or overlying of a particular layer. NISLTFE is composed of following three layers:
1. Client side interface layer
2. Server side application layer
3. Database layer

4.2.1 Client Side Interface Layer (CSIL)
The CSIL has been developed using HTML and JavaScript. The CSIL enables the designing of front end and validation of data entry forms. NISLTFE runs at any node of the network through browser. To run the NISLTFE with full functionality one must have Internet Explorer 5.0 or above or Netscape Navigator pre-installed.

4.2.2 Server Side Application Layer (SSAL)
SSAL is implemented using Java Server Pages (JSP). These JSP generate HTML pages according to the user’s action and request as presented in Fig. 2. This figure illustrates one of the most common ways of using JSP. Here a user (1) requests some information by filling out a form containing link to JSP and clicks the submit button (2), the server (3) locates the requested JSP (4), the active JSP is then translated into an Active X class, which is then compiled into a Servlet File. The Servlet (5) then gathers the Information needed to satisfy the user’s request and constructs a Web Page (6) containing the information. The web page is then displayed in User’s Browser (7).

![Fig. 4.2: Building web pages with JSP](image)

4.2.3 Database Layer (DBL)
Database layer is implemented using SQL Server 2000. It has been used for designing the tables, relationships, referential integrity rules and queries. The relational approach was
used to design the database and the fundamentals of normalization. All the tables have proper interactions amongst themselves via primary key and the foreign key relationship.

4.2.4 Software Interfaces
As presented in Fig. 1, the architecture of NISLTFE requires two interfaces, one between CSIL and SSAL and other between SSAL and DBL. The CSIL-SSAL interface is implemented using JSP. The SSAL-DBL interface is implemented using Java Database Connectivity (JDBC) which is a set of specifications that defines how a program written in Java can communicate and interact with the Database. More specifically the JDBC defines how an application opens a connection, communicates with database, executes SQL statements, retrieves Queries/Results and provides a vehicle for the exchange of SQL statements between Java application and Databases.

4.3 Database Design and Development
The database of NISLTFE has been implemented using SQL server 2000. The spectrum of the database comprises of database tables on different entities of Long Term Fertilizer Experiments and the fields of the tables cover details of all attributes of the concerned experiment. A primary key in each table is identified for uniquely defining a record. Similarly the foreign keys are identified from other tables for setting relationship amongst the different entities.

4.3.1 Designing of Tables
SQL Server 2000 has been used to design database tables with rows and columns to store data where each column represents a field and each row a record. The records under each field within different information tables are to be filled by the user online through various forms under Data Management Module. Besides the above database tables which have been used in the system for storing experiment related information, 29 master tables have also been designed. The data stored in these master tables can be used at various places while entering or updating the data related to an experiment. ER-diagram showing relationships amongst the tables of database are given below:

![ER-diagram showing relationships among Tables](image-url)
5. Designing and Development of user Interface

The user interface of NISLTFE has been designed to cater to various needs of different types of users. It is a user friendly interface that provides various options and directions to accomplish various tasks. The user interface has been divided amongst the static and the dynamic parts based on the way the information is provided to the user. The system provides a login form as a security barrier before entering into any of the modules. Only the authorized users (System Administrators/ Nodal Officers) of the system can enter into the modules after entering their user ID and password.

![Login form for entering into NISLTFE](image1)

**Fig. 5.1: Login form for entering into NISLTFE**

5.1 Static Part of Interface

The static part provides the information in the form of HTML pages (they don’t have any link with the database). The static information is present on the Home page (given below) under the following menus:

![Home page of NISLTFE](image2)

**Fig. 5.2: Home page of NISLTFE**
• Introduction
It gives information about the Long Term Fertilizer Experiments as well as on National Information System on Long Term Fertilizer Experiments.

• Contact Us
For any queries/assistance regarding the functionality of the site, the user can contact the System Administrator at IASRI and for authentication in respect of experimental data retrieval, the guest user can contact any of the persons listed in the Contact Us link.

• Help
This module helps the user in operating different modules of the NISLTFE system. For this the user will have to click on the Help menu provided in the Home Page. The contents of this module have been elaborated in the easiest possible manner to accomplish certain tasks in the system.

5.2 Dynamic Part of Interface
The dynamic part of the user interface is entirely linked to the database. It comprises of the following two modules:

5.2.1 Data Management Module
This module is an important dynamic part of the user interface meant for online data entry/updating through various forms and can be accessed only by the System Administrator and nominated Nodal Officers. No guest user is allowed to enter this module. Under this module four types of online operations can be performed.

1. Master entry/updating under Master Tables in database of the system
2. Addition of New Experiment Information
3. Addition of Subsequent Experiment Information (year/season wise)
4. Updating of Experiment Information already stored

The System Administrator can perform all of the above four operations, whereas nominated Nodal Officers having authenticated passwords can operate the last three options for their respective centers only. The deletion option has not been provided since the experiments are of continuing nature. However, if some mistakes occur while entering the data the same can be rectified using the updating option. Moreover, the permanent deletion of any data can only be done by the System Administrator only.

The online data entry and updating tasks for experiment related information is done through the following forms:

• Experiment id information form containing the names of ICAR Division, Organization Type, Centre and the Site of the experiment
• Centre information form consisting of its ecosystem, eco-region, eco-sub-region soil taxonomy, longitude, latitude and altitude
• Experiment Principal Investigator information form regarding its name, designation, postal address, email id, telephone and fax numbers.
• Experiment general information form about title, objectives, year of start/termination, statistical design, field layout plan, plot size etc.
• Crop related information form like variety, standard week of sowing/harvesting, plant spacing, crop condition/damage etc.
• Treatment details information form involving input doses, sources, methods of application and treatment deviations etc.
• Data value information form containing plot wise/ mean data for different characters
• Mid course modification information form regarding changes carried out in the ongoing experiment
• Superimposed treatments data value form for each character
• Weekly weather data information form and
• Information form relating to new user like creating password, electronic/ surface mail, telephone and fax numbers of new user

For illustration, an experiment id form (one of the aforementioned forms) duly filled is shown below:

![Experiment ID form](image)

**Fig. 5.3: Experiment ID form**

### 5.2.2 Reports Module

The Reports module handles the information retrieval tasks from the database and its display to the user. The reports are both of fixed and user-customized type. Different types of users would be able to generate reports of their own interest in a proper and structured manner. However, the guest user would not be allowed to view character wise experiment data value reports. For this, the guest user will have to secure an id and password from any of the persons under Contact Us module. The reports option form provides the user with various options for generating different types of reports viz.

- Experiment General Information Reports
- Experiment Crop Information Reports
- Experiment Information (Agro-Eco System-wise)
- Experiment Information (ICAR Division-wise)
- Experiment Weather Information Reports
- Experiment Character Data Value Reports
• Mid-course modification information and Super-imposed treatments Data Value Reports
• Experiments Field Layout Plan Reports

The help menu guides the user in generating the required reports. One of the reports generated for data value of a long term experiment conducted with RCBD design at Ludhiana centre has been illustrated below:

![Table]

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Year</th>
<th>Character Name</th>
<th>Treat Sr.No</th>
<th>Rep.No.</th>
<th>Replication Wise Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>1</td>
<td>1</td>
<td>27.7</td>
</tr>
<tr>
<td>2</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>1</td>
<td>2</td>
<td>26.4</td>
</tr>
<tr>
<td>3</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>1</td>
<td>3</td>
<td>24.9</td>
</tr>
<tr>
<td>4</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>1</td>
<td>4</td>
<td>24.2</td>
</tr>
<tr>
<td>5</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>2</td>
<td>1</td>
<td>38.65</td>
</tr>
<tr>
<td>6</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>2</td>
<td>2</td>
<td>40.0</td>
</tr>
<tr>
<td>7</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>2</td>
<td>3</td>
<td>37.6</td>
</tr>
<tr>
<td>8</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>2</td>
<td>4</td>
<td>32.45</td>
</tr>
<tr>
<td>9</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>3</td>
<td>1</td>
<td>37.8</td>
</tr>
<tr>
<td>10</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>3</td>
<td>2</td>
<td>37.7</td>
</tr>
<tr>
<td>11</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>3</td>
<td>3</td>
<td>36.6</td>
</tr>
<tr>
<td>12</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>3</td>
<td>4</td>
<td>33.8</td>
</tr>
<tr>
<td>13</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>4</td>
<td>1</td>
<td>37.3</td>
</tr>
<tr>
<td>14</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>4</td>
<td>2</td>
<td>34.7</td>
</tr>
<tr>
<td>15</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>4</td>
<td>3</td>
<td>37.8</td>
</tr>
<tr>
<td>16</td>
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<td>4</td>
<td>39.2</td>
</tr>
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<td>41.6</td>
</tr>
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<td>5</td>
<td>2</td>
<td>34.65</td>
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<td>19</td>
<td>1971-72</td>
<td>Grain Yield(q/ha)</td>
<td>5</td>
<td>3</td>
<td>44.0</td>
</tr>
</tbody>
</table>

**Fig. 5.4: Experiment character data value reports**

The generated report can be saved with an `.xls` extension in Excel and can be utilized for further analysis with any of the software packages.