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# NISLTFE: A Web based Information System for Long Term Fertilizer Experiments in India

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**SUMMARY**

A large number of Long Term Fertilizer Experiments (LTFE) on various Food, Horticulture and Commercial Crops are being conducted at various Indian Council of Agricultural Research (ICAR) Institutes and State Agricultural Universities (SAU). Usually the information generated from these experiments is not available in compatible form at one place to the scientific community working in National Agricultural Research System (NARS). Also planners/ research workers may be interested in this information as this will help them in planning/conducting the future long term experiments.

Keeping the importance of this information in view, a Web based information system entitled "National Information System on Long Term Fertilizer Experiments (NISLTFE)" has been designed, developed and uploaded at Indian Agricultural Statistics Research Institute (IASRI) domain http://www.iasri.res.in:8081/nisltfe/. NISLTFE would generate information for various policy decisions in the context of achieving higher productivity and maintaining sustainability under modern intensive cropping system based on high external inputs of fertilizers, agro-chemicals and high yielding cultivars under irrigated/ rain fed conditions etc.

This paper focuses on the variety of information provided by NISLTFE in the form of online reports. Emphasis is on parameters, such as crop sown, statistical design used, agro-ecosystem, weather, characters, mid course modifications, field layout and character data stored for the LTFE.

*Key words:* Information system, Soil fertility, Crop productivity, Long term fertilizer experiments, Java server pages, Superimposed treatments, Character data.

## 1. INTRODUCTION

Improving and maintaining soil fertility for enhancing and sustaining crop production is of worldwide importance. Many factors influence the complex chemical, physical and biological processes that govern the soil fertility and productivity. Changes in fertility caused by imbalanced fertilizer use, acidification, alkalinity, salinity and declining soil organic matter (SOM) may take several years to appear. These properties in turn can be influenced by external factors such as atmospheric pollution, global climatic changes or land use management practices. In this context, Long Term Fertilizer Experiments (LTFE) are the valuable repositories of information regarding the sustainability of input intensive agriculture. They 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 economic returns. They provides the best possible means of studying yield sustainability along with changes in soil properties and in identifying the emerging trends in nutrient imbalances and deficiencies so as to formulate future studies for maintaining sustainable crop productivity and soil fertility.

Therefore, the information pertaining to the LTFE has to be stored in an organized way so as to retrieve it with required parameters in a user-friendly way at any future instant of time. Thus, a Web based information system viz., National Information System for Long Term Fertilizer Experiments (NISLTFE) for LTFE conducted in India, has been developed using the latest Web based technologies that can be accessed using any Internet browser.

The system would act as a repository of information on various Nutrient Management Technologies being developed in the various disciplines of soil, agronomy and horticulture sciences in the country. This would serve as reference material for scientists working in National Agricultural Research System (NARS) in planning out their future research program. It would be of immense use to research managers in prioritizing research programs by taking an overall view of the technologies developed pertaining to the respective specific discipline in a particular region.

The centralized information could also be exploited for reviewing the types of statistical designs adopted for experimentation and suggest improvements in the designs and statistical analysis of long-term experiments for drawing more precise inferences. It would allow the user to access any information related to LTFE online. The information on these experiments can also be fruitfully utilized for teaching purposes.

## 2. NEED OF NISLTFE

A review of the databases developed for long term fertilizer experiments in India as carried out by Vats *et al.* (2006), revealed that institutions conducting long term fertilizer experiments are maintaining the information on these experiments at institute level only and as such no national database is available in India.

Several databases on long-term experiments are available on the Internet. Amongst these, the most prominent and important database is SOMNET: A Global Network and Database of Soil Organic Matter Models and Long Term Fertilizer Experimental Datasets developed during 1993 at Soil Science Department of Roth Amsted Experimental Station, IACR, Harpenden, U.K. This metadata database contains the information on about 70 long-term experiments from all around the world including five Indian permanent long term fertilizer experiments. The web address of SOMNET is http://www.rothamsted.bbsrc.ac.uk/aen/eusomnet/index.htm. The information provided therein relates to (i) title, year of start, location address of the experiment, (ii) environment (site history, ecosystem and climate region), (iii) soil characters, (iv) land use and treatment details, (v) types and frequency of vegetation and soil measurements, etc., during the experiment, (vi) experimental design with details of replication, randomization, plot dimensions and controls. However, under this database plot-wise yield, plant nutrient uptake and soil nutrients data pertaining to these experiments are not available. Hence, the idea of developing a national database covering most of the information available on LTFE was perceived.

## 3. COVERAGE OF EXPERIMENTS IN THE SYSTEM

The data pertaining to 59, 11 and 4 experiments of the Subject matter Divisions (SMD), viz., National Resource Management (NRM) Division, Crop Science (CS) Division; and Horticulture Division respectively at Indian Council of Agricultural Research (ICAR), New Delhi, have been used to list the NISLTFE software. The system provides the facility to add new experiments and modify the existing ones online, when required. So, the coverage of experiments in the system will keep on increasing with the addition of new experiments.

## 4. MATERIALS AND METHODS

NISLTFE has been developed as a Web-based application using JAVA technology. It has three-tier architecture comprising of User Interface layer, Application layer and Database layer (Fig.1). The purpose of making the system with three-tier architecture is to provide independence to all the layers so that it functions smoothly. All the layers in this architecture are independently developed using appropriate technology.

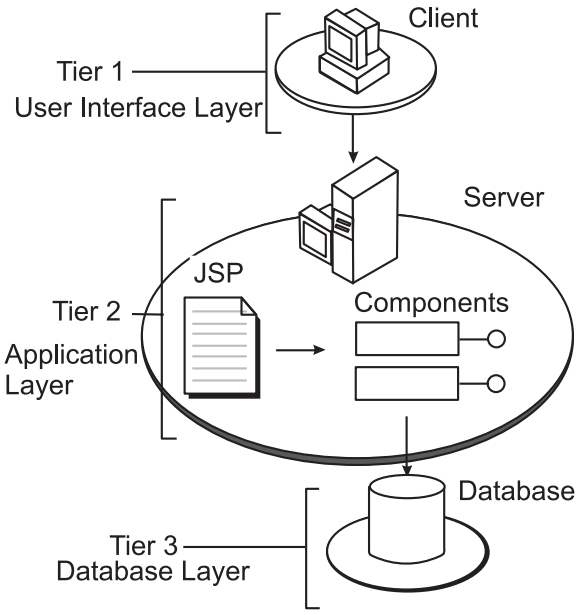



**Fig.1** Architecture of proposed NISLTFE

(i) The first tier is the client side interface layer (CSIL) that has been developed using HTML and JavaScript. The CSIL enables the designing of front end and validation of data entry forms.

(ii) The second tier is the server side application layer (SSAL) which has been implemented using Java Server Pages (JSP). These JSP generate HTML pages according to the user's action and request (Fields *et al*. 2000).

(iii) The third tier is the database layer (DBL) for which the relational and normalized database structure was used with its implementation done using SQL Server 2000 (Sequeira and Alderman 2003). All the database tables have been normalized up to the Third Normal Form (3NF) of relational database theory. For bringing the database in 3NF form, the following steps were undertaken:

- Separate tables were designed for each set of related attributes, giving each table a primary key.
- Then, any attribute dependent on only part of a multi-valued key was removed and taken to a separate table.
- Any attributes not contributing to a description of the key were removed and put into a separate table.

The database consists of 42 tables storing information on the following main attributes of LTFE

**Table 1.** A brief account of attributes involved in the database

| Main Attribute | Fields Involved |
|---|---|
| Experiment Id information | Contains the unique experiment id which is a composite key involving ICAR division code, organization type code, center code and site code of the experiment. |
| Centre special information | Consists of information about ecosystem, soil taxonomy, longitude, latitude and altitude of respective centers. |
| Experiment Principal Investigator | Contains title of the project, name of the PI of experiment, designation, correspondence, E-mail address and telephone and fax numbers. |
| Experiment basic and design information | Consists of experiment information about, objectives, year of start and termination, statistical design details, plot size and field layout plan. |
| Crop information | Contains crop related information like variety name, standard week of sowing / harvesting plant spacing, crop condition etc. |
| Treatment details information | Contains season wise treatment details with input doses, their sources, methods of application and treatment deviations if any. |
| Data value information | Contains plot wise data/mean value of different characters observed. |
| Mid-course modifications/ bifurcation | Contains the information regarding the mid-course changes carried out in the ongoing experimental program details in the experiment. |
| Superimposed treatments details information | Contains information about the superimposed treatment details with input doses and sources. |
| Superimposed treatments data value | Contains the plot wise data of each character information of superimposed treatments. |
| Weather Information | Contains weekly data about various weather parameters like temperature, relative humidity, rainfall, sunshine hours etc. |

As the LTFE have been initiated on various centers from a long time back so data on the essential attributes of these experiments has been gathered from all centers using a hardcopy data entry form. While designing the database, those attributes were selected which were describing the experiment as a whole in terms of – crop, centre, principal Investigator, treatments, modifications, weather and the data of characters observed. Also, emphasis has been given to those attributes for which data was available for almost all the years of conducting experiment.

## Results

In addition to the data management options provided by the system, information on many important aspects of LTFE can be generated in the form of well

structured tabular reports. These Experiment reports have been distributed into the following categories (Table 2).

**Table 2.** Experiment reports categories

| | | |
|---|---|---|
| i | General Information Reports | Provides a general overview of the location, duration, objectives, Principal Investigator (PI), statistical design used, soil, treatments, mid-course bifurcations, Superimposed treatments. |
| ii | Crop Information Reports | Provides all crop specific information such as year, season of sowing, Crop variety, row spacing, plant spacing, sowing week etc. |
| iii | Agro-Eco System Wise Experiment Information | Gives brief description of the experiments conducted under a particular Agro-ecosystem. |
| iv | ICAR Division Wise Experiment Information | Gives a brief description of the experiments conducted under a particular Subject Matter Division (SMD) of ICAR. |
| v | Weather Information Reports | This report generates the weather information on rainfall, maximum and minimum temperature, maximum and minimum relative humidity, mean wind velocity for a particular center during a desired standard week/month duration. |
| vi | Character Data Value Reports | This report gives the treatment and replication wise data for a particular character chosen for a particular experiment, during particular duration, season, for a particular soil depth and crop stage. |
| vii | Mid Course Modifications (superimposed treatments) Data Value Reports | This report shows the original treatment and the treatment superimposed on the original (as Mid- course modification) along with the replication numbers and superimposed data. |
| viii | Field Layout Plan Reports | This report displays the field layout plan for the selected experiment. |

A general overview of all categories of reports as shown in Table 2 along with the pictorial description of some important reports generated under these categories has been provided.

**(i) The General Information Reports** provides a general overview of the location, duration, objectives and Principal Investigator (PI), statistical design used, soil, treatments, mid-course bifurcations and Superimposed Treatments of an LTFE. The major General Information Reports are

- Center Information
- Experiment Name and Objectives Information
- Current Principal Investigator Information
- Experiment General Information
- Statistical Design Used Information
- Experiment Soil Information (Fig. 2)
- Treatment Details Report
- Mid Course Bifurcation Details Information
- Superimposed Treatment Details Information

**(ii) Experiment Crop Information Reports** provides all the crop related information for a particular experiment during a particular season of year in the form of two reports

- Crop Information Report
- Crop Condition Information Report

The Crop Information Report provides information such as: season of sowing, Crop variety Name, Row spacing, Plant spacing, Sowing week, Harvesting week and Crop duration.

The Crop Condition Information Report provides information such as: Number of Irrigations, Crop condition, Crop damage and the reasons of damage.

**(iii) Agro-Eco System Wise Experiment Information:** This report would give a brief description of the experiments conducted under a particular Agro-eco sub region falling under the selected Agro-eco region, which in turn is falling under a particular Agro-eco system of India. It is like generating a report for the Agro-eco sub region-North Punjab Plain, Ganga-Yamuna Doab and Rajasthan Upland, Hot Dry Semi-

**EXPERMENT SOIL INFORMATION**

| Sr. No. | Centre Name | Experiment Name | Taxonomy Class Name | Soil Texture | Soil Type Name |
|---|---|---|---|---|---|
| 1 | Jabalpur | To study changes in soil quality-crop productivity and sustainabilty | Typic Chromosterts | Clay | Vertisols |
| 2 | Ludhiana | To study changes in soil quality-crop productivity and sustainabilty | Udic Ustochrepts | Sand Loam | Inceptisols |
| 3 | Ranchi | To study changes in soil quality-crop productivity and sustainabilty. | Haplustalf | Sandy Clay Loam | Alfisols |
| 4 | Udaipur | To study changes in soil quality-crop productivity and sustainabilty | Typic Ustochrept | Sany Clay Loam | Inceptisls |
| 5 | Jagital | To study changes in soil quality-crop productivity and sustainabilty | Troaquept | Clay Loam | Inceptisols |

**Fig. 2.** Specimen Soil Information Report

arid Eco Sub Region falling under the Agro-Eco region – Northern Plain and Central Highland eco-region, which in turn is falling under the Agro-eco system – Semi Arid Eco system.

**(iv) ICAR Division Wise Experiment Information:** This report would give a brief description of experiments conducted under the Horticulture, NRM or Crop Science Division of ICAR. The report will display the following information: Division Name, Organization Type, Organization Name, State, Center, Experiment Title, and Year of Start and Year of Termination of the experiment.

**(v) Weather Information Reports:** This report generates the weather information for a particular center during a desired year and particular standard week/ month duration.

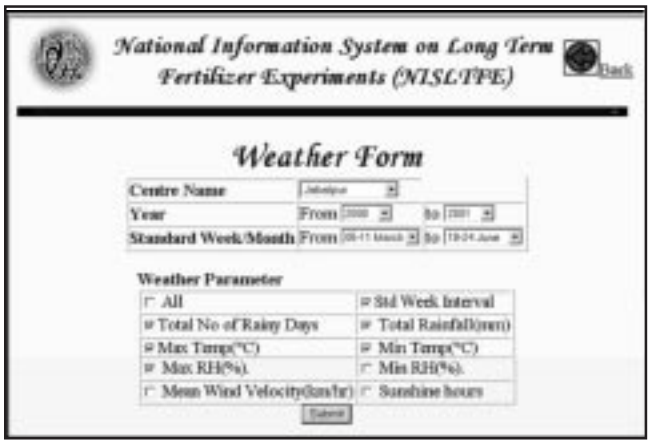
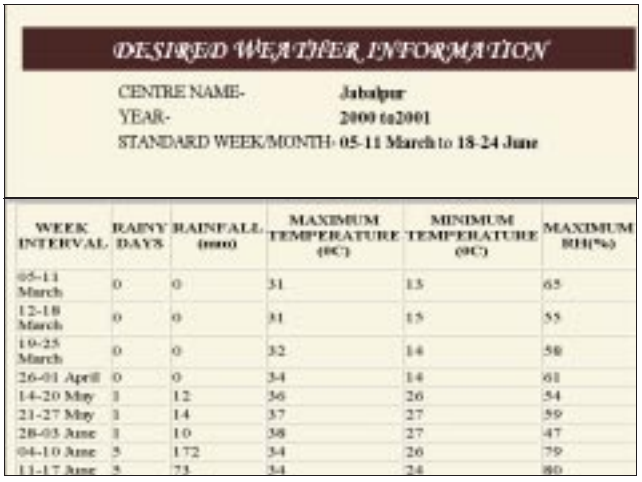



**Fig. 3.** Weather parameters selection form

The desired weather information constitutes the following information (as per the options selected by the user from the weather form (Fig.3): Total number of rainy days, total rainfall, maximum temperature and minimum temperature, maximum relative humidity (RH), minimum relative humidity, mean wind velocity and the sunshine hours.

After selecting the required parameters from the Weather Form (Fig. 3) the following Weather Report (Fig. 4) is generated:


DESIRED WEATHER INFORMATION

CENTRE NAME- Jabalpur
YEAR- 2000 to2001
STANDARD WEEK/MONTH- 05-11 March to 18-24 June

| WEEK INTERVAL | RAINY DAYS | RAINFALL (mm) | MAXIMUM TEMPERATURE (0C) | MINIMUM TEMPERATURE (0C) | MAXIMUM RH(%) |
|---|---|---|---|---|---|
| 05-11 March | 0 | 0 | 31 | 13 | 65 |
| 12-18 March | 0 | 0 | 31 | 15 | 55 |
| 19-25 March | 0 | 0 | 32 | 14 | 58 |
| 26-01 April | 0 | 0 | 34 | 14 | 61 |
| 14-20 May | 1 | 12 | 36 | 26 | 54 |
| 21-27 May | 1 | 14 | 37 | 27 | 59 |
| 28-03 June | 1 | 10 | 38 | 27 | 47 |
| 04-10 June | 5 | 172 | 34 | 26 | 79 |
| 11-17 June | 5 | 73 | 34 | 24 | 80 |

**Fig. 4.** A Specimen Weather Report

**(vi) Character Data Value Reports:** This report (Fig. 5) shows the treatment and replication wise data for a particular character chosen for a particular experiment, a particular duration, season, and soil depth and crop stage. This is a very significant report for the users of system. After generating this report, it can be

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| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 16 | Sr.No. | Year | Character Name | Treat Sr.No | Rep.No. | ReplicationWise Data |
| 17 | 1 | 2000-01 | Grain Yield(q/ha) | 1 | 1 | 42.4 |
| 18 | 2 | 2000-01 | Grain Yield(q/ha) | 1 | 2 | 36.8 |
| 19 | 3 | 2000-01 | Grain Yield(q/ha) | 1 | 3 | 35.68 |
| 20 | 4 | 2000-01 | Grain Yield(q/ha) | 1 | 4 | 33.28 |
| 21 | 5 | 2000-01 | Grain Yield(q/ha) | 2 | 1 | 40.16 |
| 22 | 6 | 2000-01 | Grain Yield(q/ha) | 2 | 2 | 40.4 |
| 23 | 7 | 2000-01 | Grain Yield(q/ha) | 2 | 3 | 41.2 |
| 24 | 8 | 2000-01 | Grain Yield(q/ha) | 2 | 4 | 38.88 |
| 25 | 9 | 2000-01 | Grain Yield(q/ha) | 3 | 1 | 54.33 |
| 26 | 10 | 2000-01 | Grain Yield(q/ha) | 3 | 2 | 44.8 |
| 27 | 11 | 2000-01 | Grain Yield(q/ha) | 3 | 3 | 45.12 |
| 28 | 12 | 2000-01 | Grain Yield(q/ha) | 3 | 4 | 42 |
| 29 | 13 | 2000-01 | Grain Yield(q/ha) | 4 | 1 | 50.5 |
| 30 | 14 | 2000-01 | Grain Yield(q/ha) | 4 | 2 | 43 |
| 31 | 15 | 2000-01 | Grain Yield(q/ha) | 4 | 3 | 42.68 |
| 32 | 16 | 2000-01 | Grain Yield(q/ha) | 4 | 4 | 41.8 |
| 33 | 17 | 2000-01 | Grain Yield(q/ha) | 5 | 1 | 43.16 |
| 34 | 18 | 2000-01 | Grain Yield(q/ha) | 5 | 2 | 45.8 |

data_Report

**Fig. 5**.The Character Data Value Report (MS-Excel Worksheet accessed in Web-browser)

accessed as MS-Excel Worksheet on the Web browser itself or can be saved as an MS-Excel file at the desired location of the user's computer. This additional facility is provided for statistically analyzing the data online or offline using Microsoft Excel.

**(vii) Mid-Course Modifications (superimposed treatments) Data Value Reports:** Mid course modifications/corrections in LTFE is a basic requirement if these experiments are continued for 20, 30 or even more years without making adjustments for fertilizers-soil nutrient interactions that are significant, otherwise experiments may remain only of historical importance but of little consequence to the farming community.

This report (Fig. 6) shows the original treatment and the treatment superimposed on the original (as mid course modification) along with the replication numbers. The superimposed data for the selected character category is also shown in the report.

**(viii) Field Layout Plan Reports:** This report displays the field layout plan for the selected experiment in the form of an image. It provides three options of displaying Initial Layout, Midcourse Modifications Layout and the option to display both the layouts to the user.

## 5. VALUE ADDITION

Almost all the online systems provide data in the form of online reports, but most of them don't provide the facility to analyze the data at the browser itself. So for analyzing the data provided by the information systems, user has to enter the whole data into some data analysis software present on their PC and then it can be analyzed.

But, NISLTFE system provides the facility of data analysis using MS-Excel at the browser itself. Also, there is no need of entering the huge data in the MS-Excel sheet. If the user wants to analyze the data presented by the Data Value Reports, he has to select the option of Data Analysis provided at the bottom of the Data Value Report (Fig. 7) and MS-Excel sheet will get opened in the browser itself along with the data presented by that particular report arranged properly in columns and rows of that particular worksheet (Fig. 5). So, the user can perform Data Analysis operations in the Excel worksheet at the browser itself.

## 6. CONCLUSION

NISLTFE has the advantage of providing the latest information on Long Term Fertilizer Experiments to its

| |
|---|
| **Centre Name :** Ludhiana |
| **Title of Experiment :** To study changes in soil quality-crop productivity and sustainability |
| **Season :** Kharif/Rainy |
| **Crop Name :** Maize |
| **Crop Stage :** After harvest |
| **Character Category :** Yield |
| **Character Name :** Grain Yield Unit : (q/ha) |
| **Soil Depth :** Not Applicable |
| **Year From :** 1993-94 To 2003-04 |

| Sr. No. | Year | Org. Treat Sr.No. | Org Treat Name | Treat Sr. No.Super imposed | Treat Name Super imposed | Replication No. | Super imposed Data |
|---|---|---|---|---|---|---|---|
| 1 | 1993-94 | T1 | 50% Optimal NPK+HW | S1 | 50% NPK (Original) | 1 | 6.173 |
| 2 | 1993-94 | T1 | 50% Optimal NPK + HW | S1 | 50% NPK (Original) | 2 | 7.909 |
| 3 | 1993-94 | T1 | 50% Optimal NPK + HW | S2 | 100% N + 50% PK (Original) | 1 | 9.934 |
| 4 | 1993-94 | T1 | 50% Optimal NPK + HW | S2 | 100% N + 50% PK (Original) | 2 | 8.873 |
| 5 | 1993-94 | T1 | 50% Optimal NPK + HW | S3 | 100% N + 50% PK + Zn | 2 | 11.767 |
| 6 | 1993-94 | T1 | 50% Optimal NPK + HW | S3 | 100% N + 50% PK + Zn | 2 | 7.417 |
| 7 | 1993-94 | T3 | 50% Optimal NPK + HW | S1 | 150% NPK (Original) | 1 | 9.549 |
| 8 | 1993-94 | T3 | 50% Optimal NPK + HW | S1 | 150% NPK (Original) | 2 | 15.046 |
| 9 | 1993-94 | T3 | 150% Optimal NPK + HW | S2 | 150% NK + 100 %P | 1 | 9.838 |
| 10 | 1993-94 | T3 | 150% Optimal NPK + HW | S2 | 150% NK + 100 %P | 2 | 10.224 |
| 11 | 1993-94 | T3 | 150% Optimal NPK + HW | S3 | 150% NK + 100 % P + Zn | 1 | 10.153 |

**Fig. 6** Mid-course Modifications Data Value Report

users. Data management, maintenance and retrieval have become much easier and faster. Quality Reports on every aspect of LTFE can be generated online. It also provides the facility of analyzing the data online using Microsoft Excel. It will help planners/research workers in planning/conducting the future LTFE. Also, it will act as a repository of information on various Nutrient Management Technologies. Further the centralized information can be exploited for reviewing statistical designs adopted and suggesting improvements in the designs for drawing more precise inferences.

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