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ICT Initiatives on Experimental designs for Agricultural Experiments at ICAR-IASRI

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The essential feature of any scientific investigation is experimentation and drawing valid inferences based on the experimentation. The general procedure is to formulate the hypothesis according to the problem whose answer is to be sought for and to verify the formulated hypothesis. An experiment is then designed based on the objectives, availability of experimental material, cost of the experiment etc. In order to test hypothesis with acceptable degree of precision, one has to carefully design the experiment. Thus, designing an experiment is an essential component of any scientific investigation.

Designing an experiment implies deciding how the experimental units are arranged, the treatments are allocated to these and the observations or measurements are taken to solve a particular problem in a valid, efficient and economic way. Hence a scientific approach is essential to design an experiment.

Design of experiments, an important branch of statistics, found profound applications in agricultural and allied researches. With the advent of time, the subject of design of experiments, has grown both horizontally and vertically. Researchers from different disciplines have adapted not only basic designs for their experiments but also various advanced designs based on the requirement of their experiments.

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ICT INITIATIVES ON EXPERIMENTAL DESIGNS FOR AGRICULTURAL EXPERIMENTS AT ICAR-IASRI

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Now a days, with the advancement of technologies, development of different ICT based online solutions for generating specific designs according to the situations, is the need of the hour as these ICT tools are helpful in providing readymade solutions to the experimenter. ICAR-Indian Agricultural Statistics Research Institute, New Delhi has done significant work in this direction by developing various ICT based web solutions to generate different types of designs. These web solutions not only provide readymade solution to various researchers across the globe but also

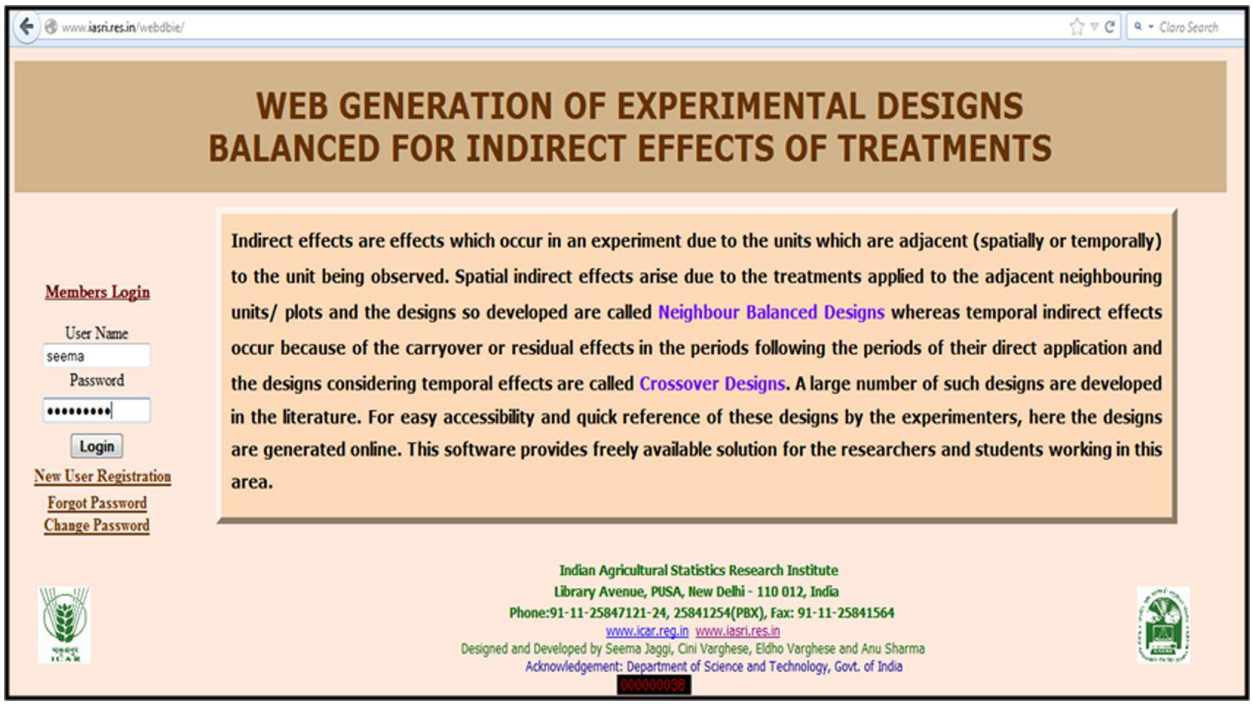
help in adaptation of different designs by the research community. This article highlights some of the recent ICT initiatives at ICAR-IASRI in the field of experimental designs.

1. WEB GENERATION OF EXPERIMENTAL DESIGNS BALANCED FOR INDIRECT EFFECTS OF TREATMENTS (WEB-DBIE)

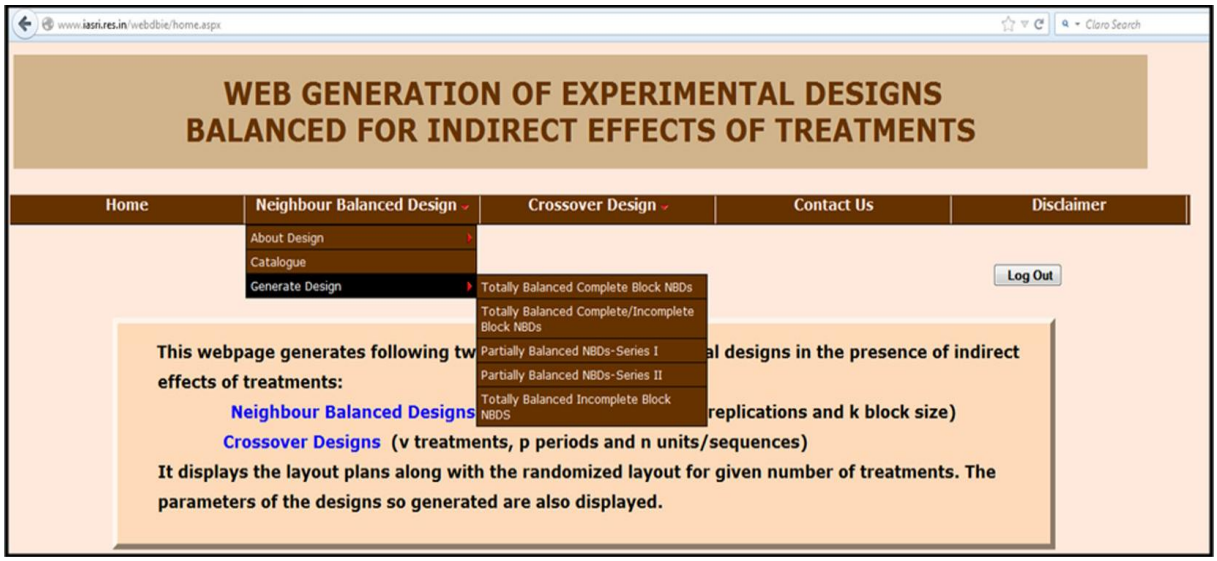
In designing of any scientific experiment, heterogeneity in the experimental material is an important aspect to be taken care of. Block designs are used as a classical device for controlling local variation in the experimental material by dividing the entire experimental material into groups/blocks such that the experimental units are homogeneous within a block. In agricultural field experiments, there may be situations where in order to control heterogeneity and conserve resources, the treatments are assessed in compact blocks with plots are packed adjacent to each other. The treatment applied to one experimental plot may affect the response of neighbouring plots as well as the response of the plot to which it is applied. For example, treatments such as fertilizer, irrigation, or pesticide may spread to adjacent plots causing neighbour effects. Effects that occur in an experiment due to the units which are adjacent spatially to the unit being observed are called spatial indirect effects. When the experimental units are long lived or scarce, in order to study the effects of different treatments, the same unit is given various treatments over different periods. Similarly, treatments applied in a particular period may influence the response of the units not only in the period of their direct application but also in the subsequent periods. The treatments like drugs or feeds, leave carryover effects in the periods following the periods of their direct application. The effects that occur in an experiment due to the units which are adjacent temporally to the unit being observed are called temporal indirect effects. Understanding the structure of these indirect effects helps in minimizing the bias in the treatment comparisons to a great extent so as to make more precise inference. It is thus important to include the indirect effects in the model to have the proper specification and to obtain designs that are balanced for indirect effects. Neighbour Balanced Designs (NBDs) are used for the situations when spatial indirect effects are suspected from the treatments applied in the neighbouring experimental units whereas Crossover Designs (CODs) are used when temporal indirect effects consisting of residual or carryover effects from the treatments applied in the previous period are present. These designs ensure that each treatment occurs adjacent to every other treatment spatially or temporarily same number of times. Considering the practical

importance of neighbour and carryover effects, a web solution named **WEB-DBIE** has been developed at ICAR-IASRI and made available at http://iasri.res.in/webdbie.

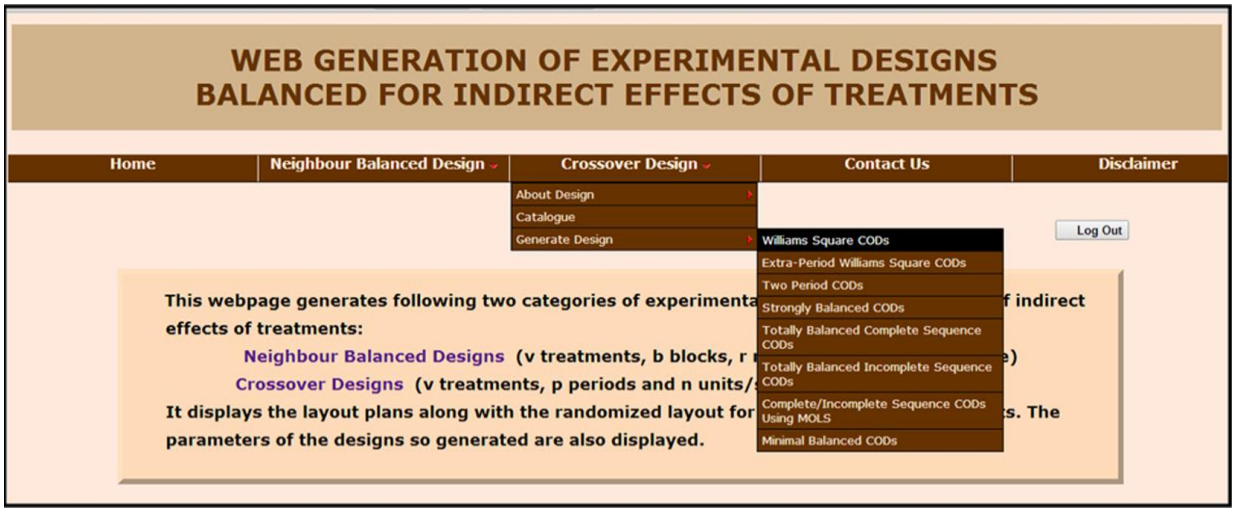
WEB-DBIE generates design and randomized layout for various classes of NBDs and CODs. It generates totally balanced/partially balanced, complete/incomplete NBDs (v treatments, b blocks, r replications and k block size). The classes of CODs (v treatments, p periods and n units/sequences) generated are Williams square, extra period Williams square, two-period designs, minimal balanced, strongly balanced, totally balanced designs in complete/incomplete sequences, designs with complete/incomplete sequences using MOLS. Output can be exported to MS-Excel spread sheet for further use. Catalogues of NBDs and CODs are made available in the software through which also these designs can be generated. The algorithms for the generation of various classes of NBDs and CODs are developed based on methods available in the literature and the details about the same are described in the option 'About Design'. Following are some of the screenshots with respect to **WEB-DBIE**.



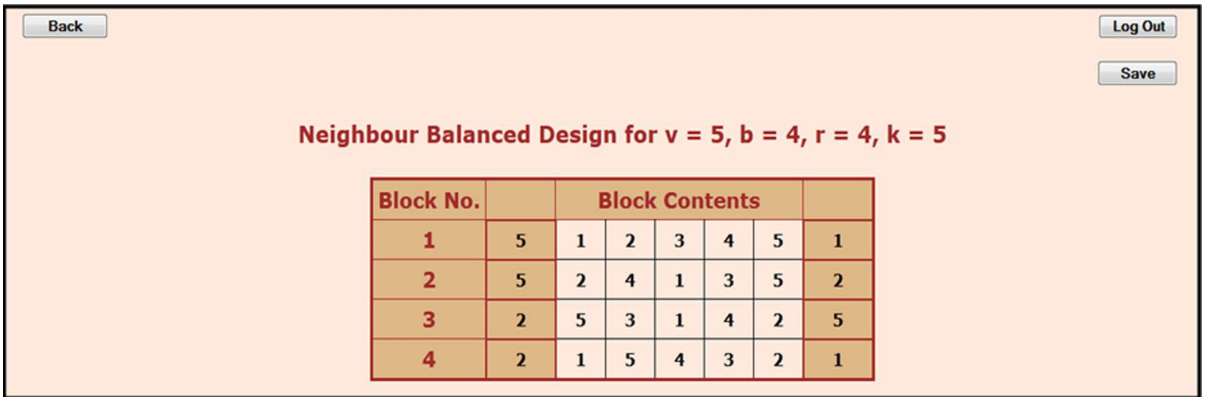
Login Page of WEB-DBIE



Neighbour Balanced Designs

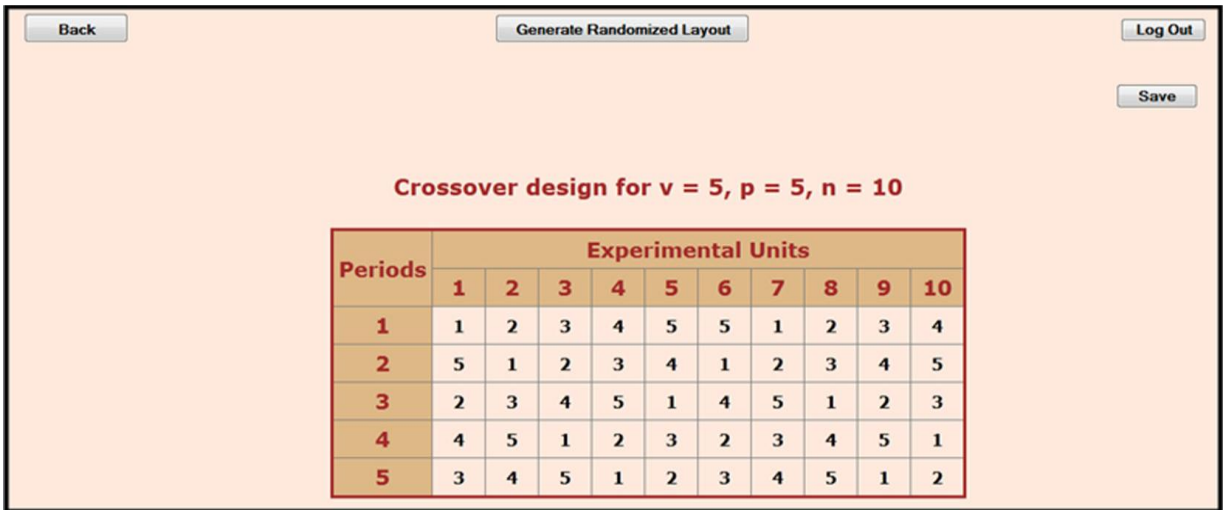


Crossover Designs



Block No.		Block Contents					
1	5	1	2	3	4	5	1
2	5	2	4	1	3	5	2
3	2	5	3	1	4	2	5
4	2	1	5	4	3	2	1

Generation of NBD



Periods	Experimental Units									
	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	5	1	2	3	4
2	5	1	2	3	4	1	2	3	4	5
3	2	3	4	5	1	4	5	1	2	3
4	4	5	1	2	3	2	3	4	5	1
5	3	4	5	1	2	3	4	5	1	2

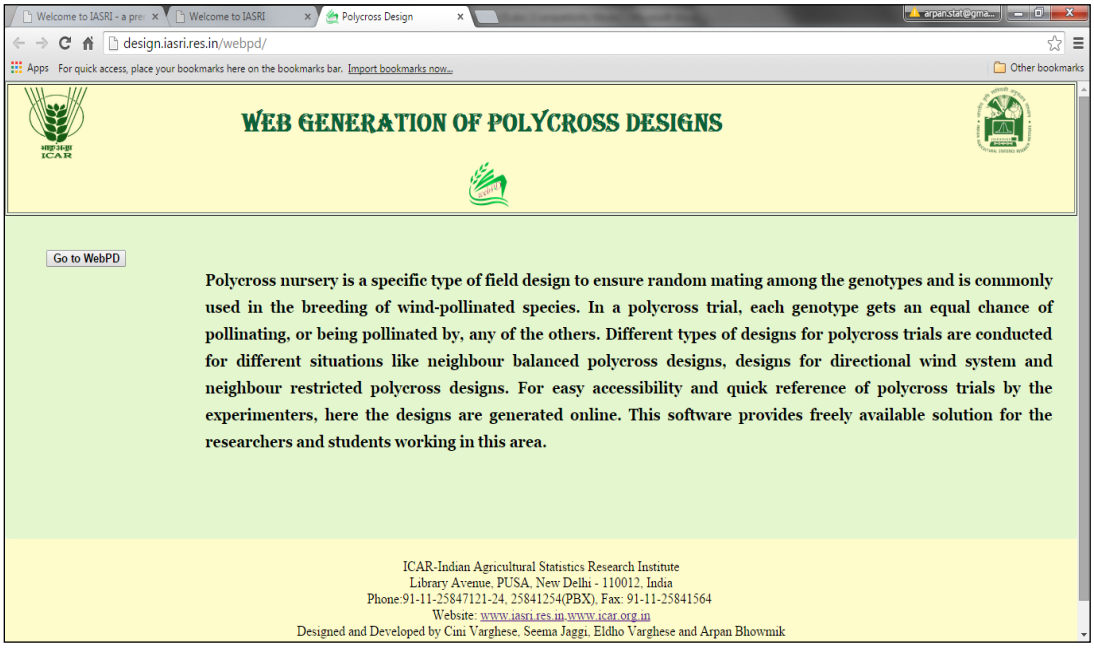
Generation of COD

2. WEB GENERATION OF POLYCROSS DESIGNS (webPD)

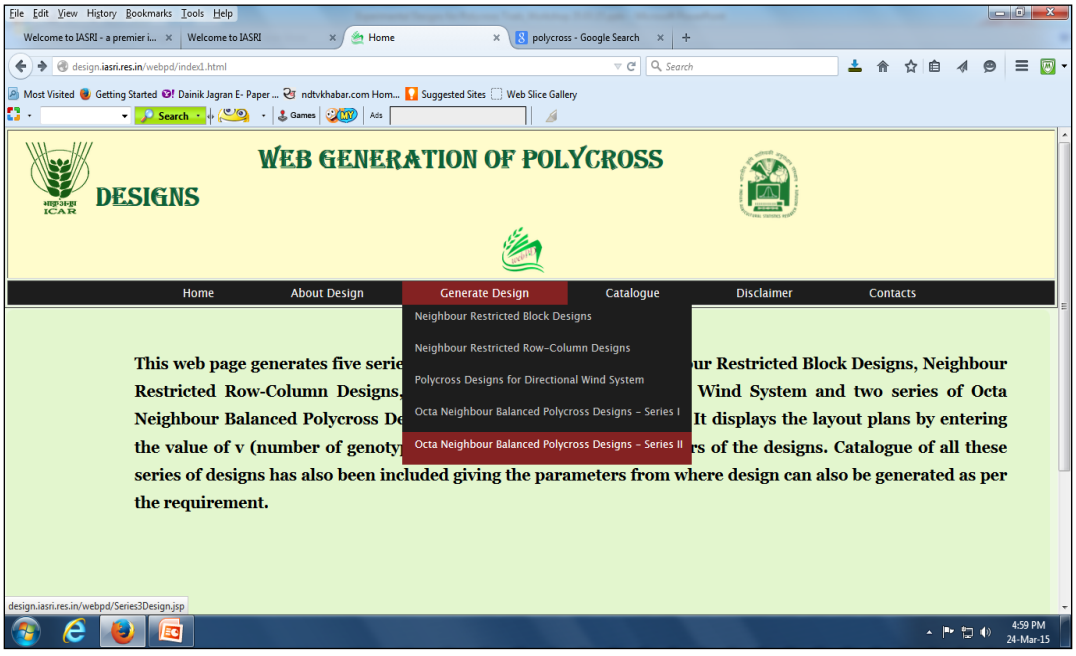
Careful choice of parental lines and efficient mating designs form the backbone to a successful plant breeding programme. Objectives of the study, nature of genotypes, pollination type, space, cost, heterogeneity present in the field, wind direction, *etc*. are some of the deciding factors of a mating design. For wind pollinated species, a group of selected genotypes are to be arranged in isolated blocks/rows and columns such that each genotype gets an equal chance of pollinating, or being pollinated by, any of the others. Different types of designs for polycross trials are conducted for different situations like octa neighbour balanced polycross designs, designs for directional wind system, neighbour restricted polycross designs, *etc*. For ready referencing and potential use of these designs, online software for generation of these designs is highly desirable. Considering this, a web solution for generation of different classes of polycross designs based on client–server architecture named as **webPD** has been developed. The software webPD is available at http://iasri.res.in/webPD and is easily accessible at any time from any arbitrary platform throughout the globe through the use of internet.

There are basically three major modules of the software namely generation of different classes of polycross designs, catalogue of such designs and a brief description about the construction of different classes of polycross designs. User can access the software by first clicking a button in the homepage entitled **Go to webPD**. In order to provide readymade solutions to the end users, webPD generates five different series of designs (with v number of treatments) *viz*., Neighbour

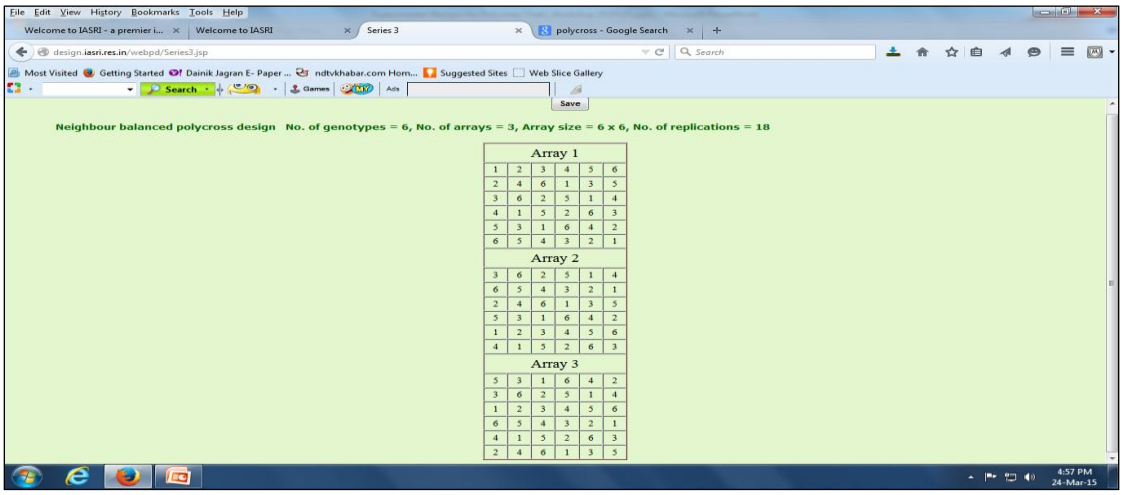
Restricted Block Designs, Neighbour Restricted Row-Column Designs, Polycross Designs for Directional Wind System and two series of Octa Neighbour Balanced Polycross Designs. Various web forms have been designed and developed for generation of these designs. Following are some of the screen shots:



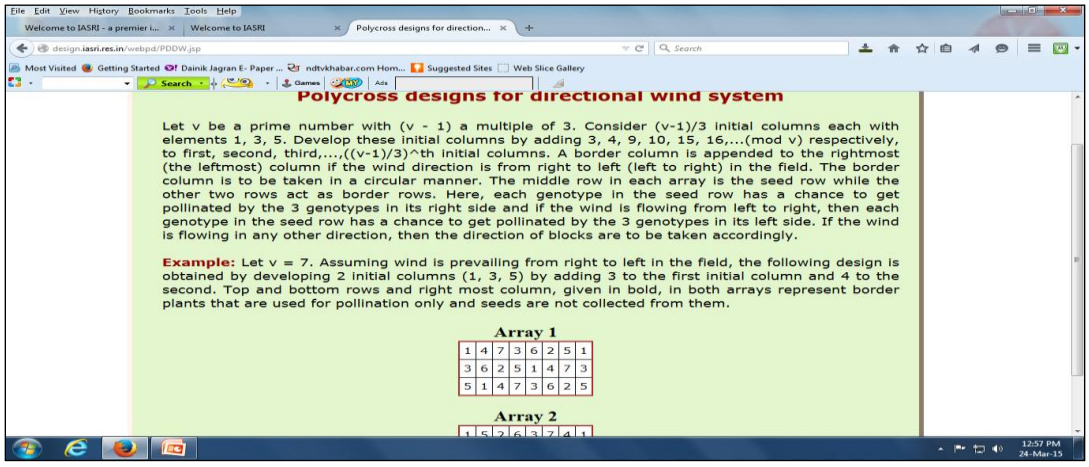
Home Page of webPD



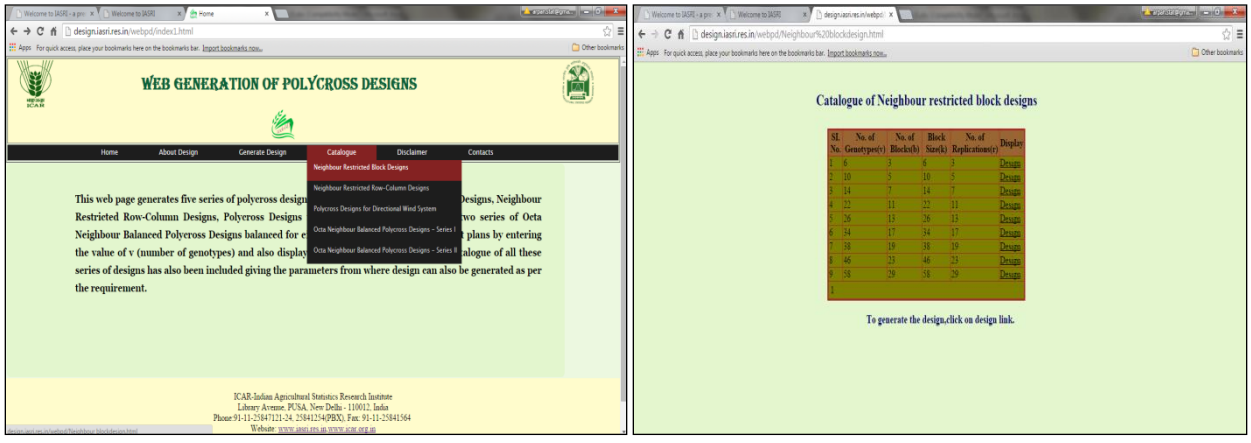
Menu Page of webPD



Generation of Octa Neighbour Balanced Designs – Series II



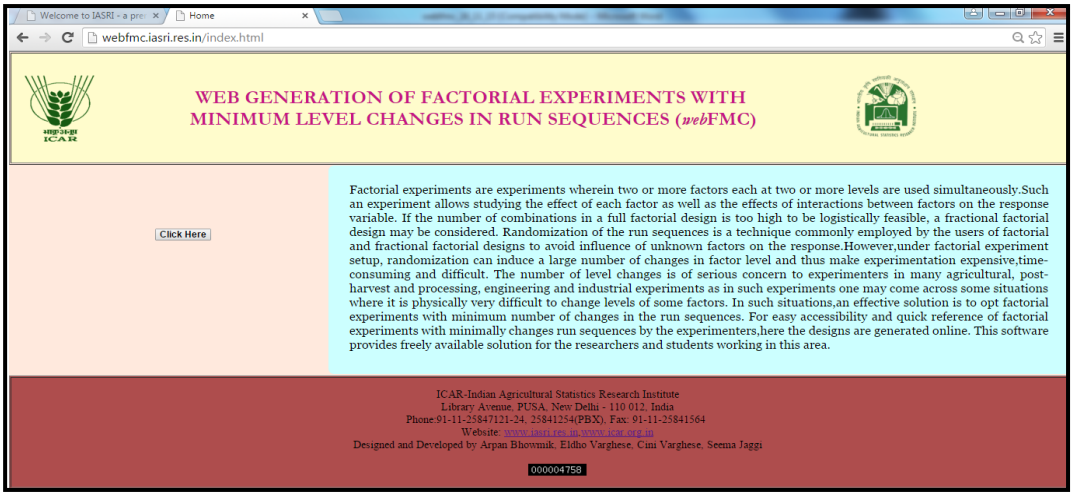
About Designs' for Directional Wind System



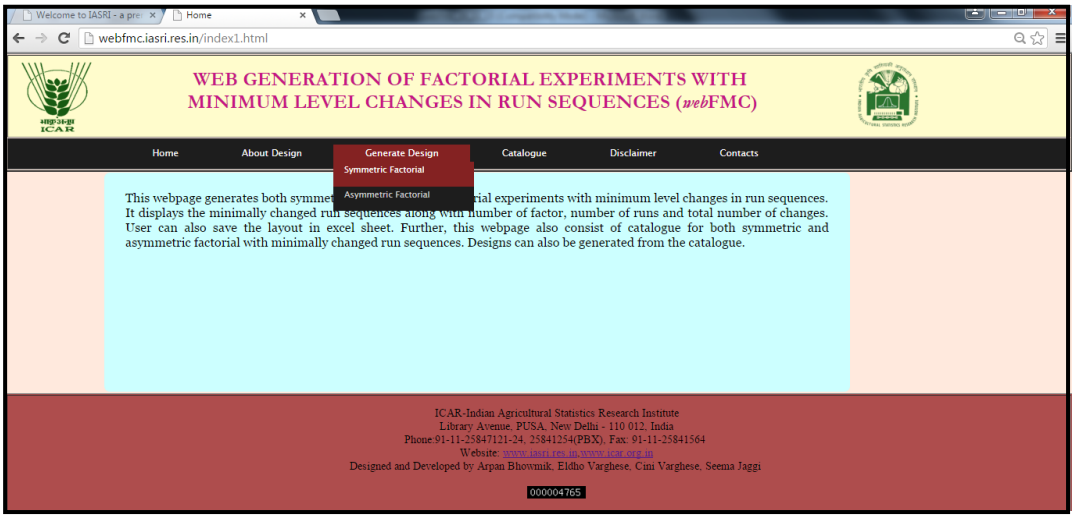
Catalogue of Neighbour Restricted Block Designs

3. WEB GENERATION OF FACTORIAL EXPERIMENTS WITH MINIMUM LEVEL CHANGES IN RUN SEQUENCES (*web*FMC)

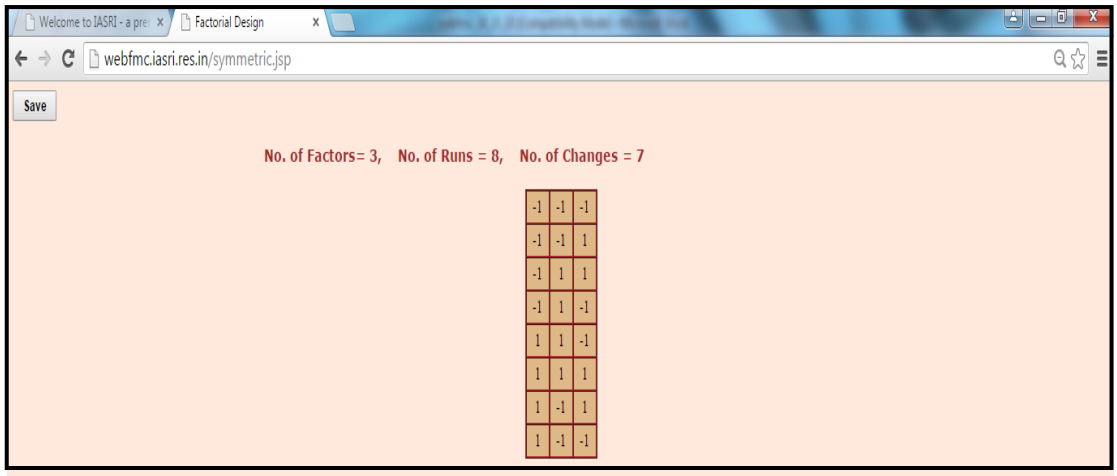
Factorial experiments, wherein two or more factors each at two or more levels are used simultaneously, have profound applications in many fields of agricultural and allied sciences. It is always advisable that the order of execution of factorial designs should be random. However, randomization can induce large number of factor level changes and thus make experimentation more expensive, time-consuming and difficult. The number of level changes under factorial experimental setup is of serious concern to experimenters in many agricultural, post-harvest and processing, engineering and industrial experiments as here one may come across some situations where experiments involves hard-to-change factors. In such situations, instead of randomization, adaption of factorial experiments with minimum number of changes in the factor levels may be an alternative. For providing readymade layout plans of factorial designs with minimum level changes in run sequences to experimenters, a web solution named *web*FMC has been developed at ICAR-IASRI and made available in the public domain at http://webfmc.iasri.res.in. The software has been developed using client–server architecture. The software *web*FMC is accessible any time from arbitrary platforms through internet. Along with the layout plans of the run sequences, the software also generates an online catalogue of such run sequences. Following are some of the screenshots of *web*FMC.



Home page of *web*FMC



Menu page of *web*FMC

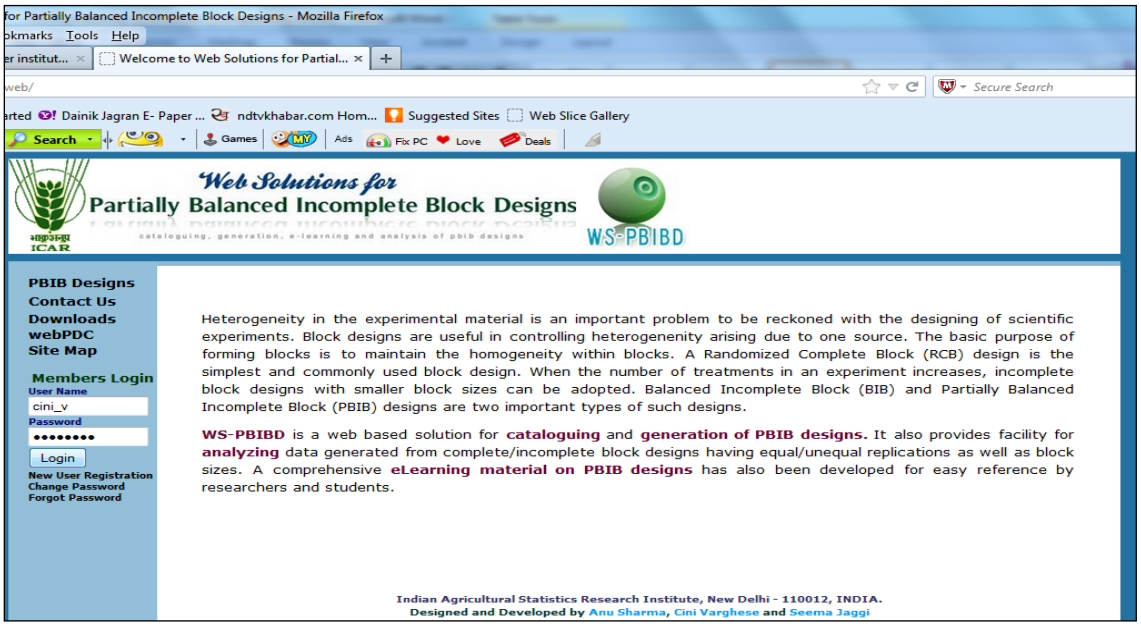


Layout of 2^3 symmetric factorial with minimum level changes along with parameters

4. WEB SOLUTION FOR PARTIALLY BALANCED INCOMPLETE BLOCK DESIGNS (WSPBIBD)

Heterogeneity in the experimental material is an important problem to be reckoned with the designing of scientific experiments. Block designs are useful in controlling heterogeneity arising due to one source. The basic purpose of forming blocks is to maintain the homogeneity within blocks. A Randomized Complete Block (RCB) design is the simplest and commonly used block design. When the number of treatments in an experiment increases, incomplete block designs with smaller block sizes can be adopted. Balanced Incomplete Block (BIB) and Partially Balanced Incomplete Block (PBIB) designs are two important types of such designs. The complexity in the methods of construction of PBIB designs reduces the advantageous application

potential of these designs. A readily available solution WS-PBIBD, a web based solution for generation of PBIB designs effectively handles this issue. Software is available at http://nabg.iasri.res.in/pbibweb/.



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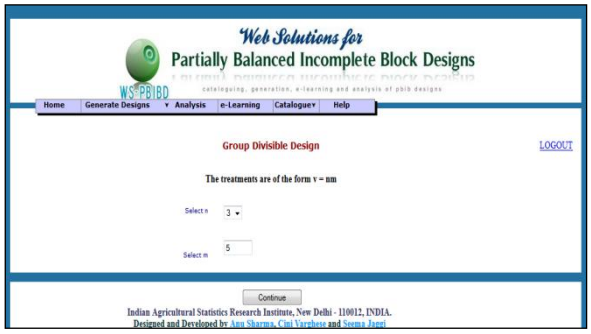
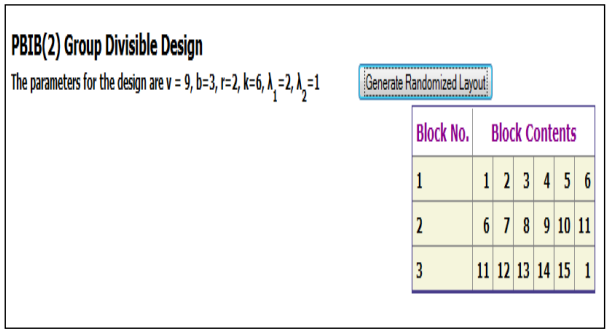


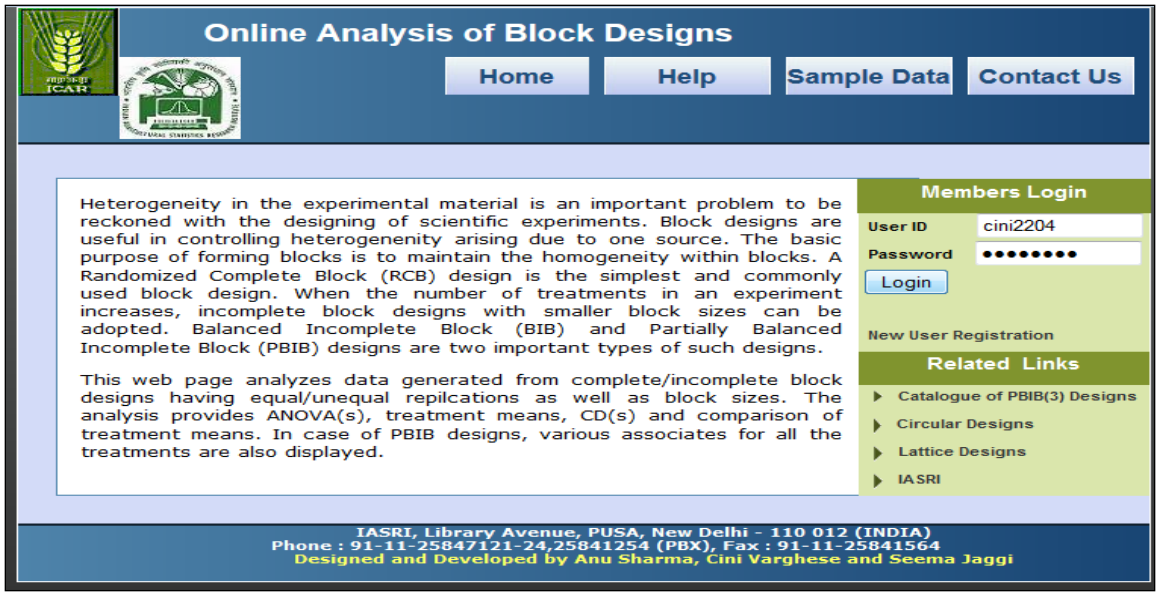
Entering Parameters



A PBIB(2) Design Generated

5. GENERAL BLOCK DESIGN ANALYSIS

On-line analysis module for block designs with complete/incomplete blocks, equal/ unequal block sizes and equal/ unequal replications has been developed for easy accessibility of the users to perform on-line analysis and deployed at http://www.iasri.res.in/WebAnalysis/index.aspx. This covers a wide range of block designs including the popular classes like RCBD, BIBD and PBIBD. This analysis module provides all that is required by the experimenters, i.e. ANOVA(s), treatment means, CD(s) and comparison of treatment means.



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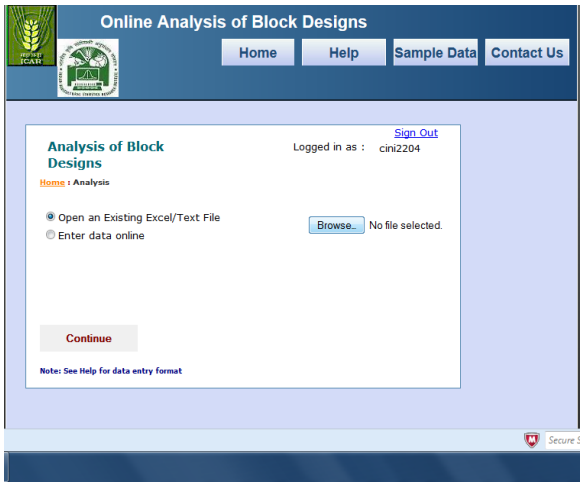
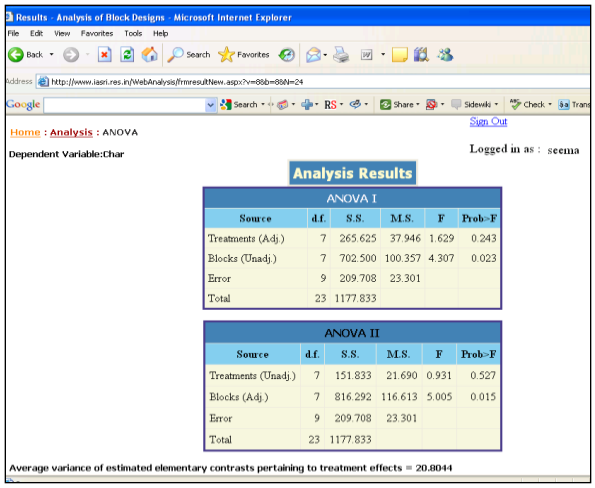


Browse Data File



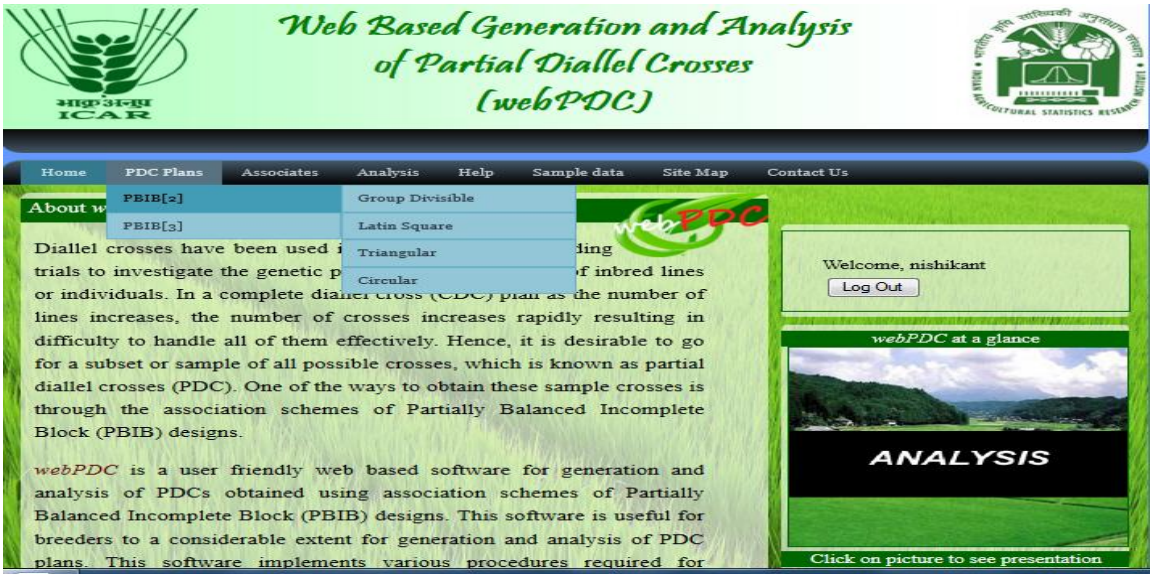
Output of Analysis

6. WEB BASED GENERATION AND ANALYSIS OF PARTIAL DIALLEL CROSSES (*web*PDC)

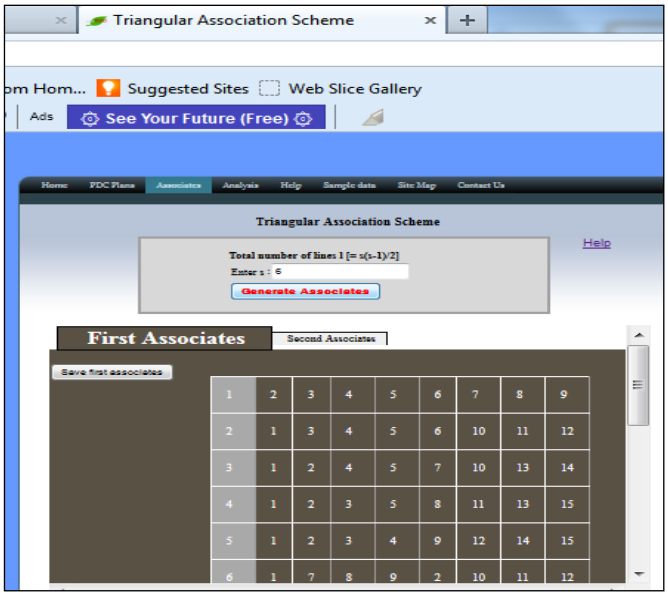
Diallel crosses have been used in plant and animal breeding trials to investigate the genetic properties and potentials of inbred lines or individuals. In a complete diallel cross (CDC) plan as the number of lines increases, the number of crosses increases rapidly resulting in difficulty to handle all of them effectively. Hence, it is desirable to go for a subset or sample of all possible crosses, which is known as partial diallel crosses (PDC). One of the ways to obtain these sample crosses is through the association schemes of Partially Balanced Incomplete Block (PBIB) designs.

Web Based Generation and Analysis of Partial Diallel Crosses (webPDC) is a user friendly web based software for generation and analysis of PDCs obtained using association schemes of Partially Balanced Incomplete Block (PBIB) designs. This software is useful for breeders to a considerable extent for generation and analysis of PDC plans. This software implements various procedures required for generation and analysis of PDCs. Web service for generation and analysis of PDCs is also provided that can be utilized by other applications. This software is made available at http://nabg.iasri.res.in/webpdc/login.aspx. Some snapshots are given below:

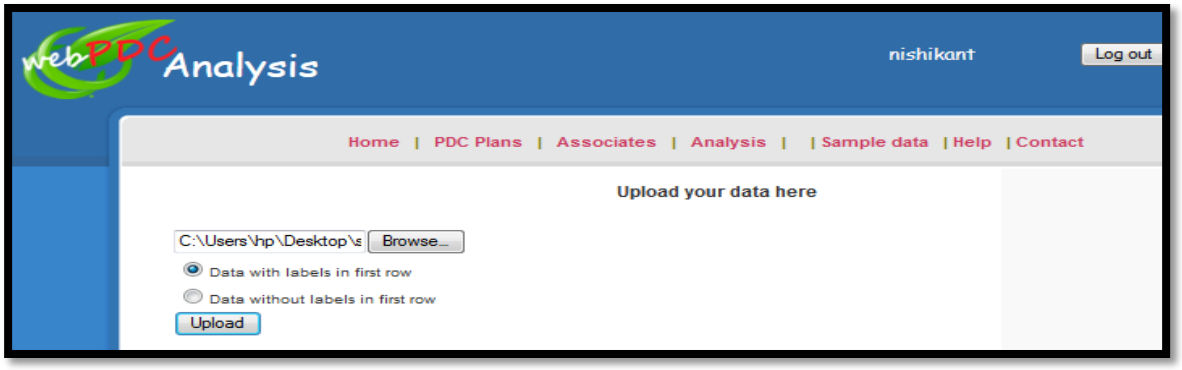
Login Page

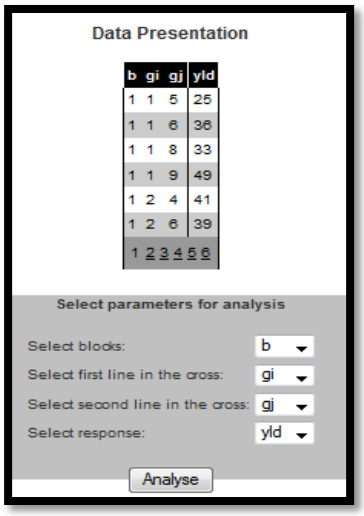


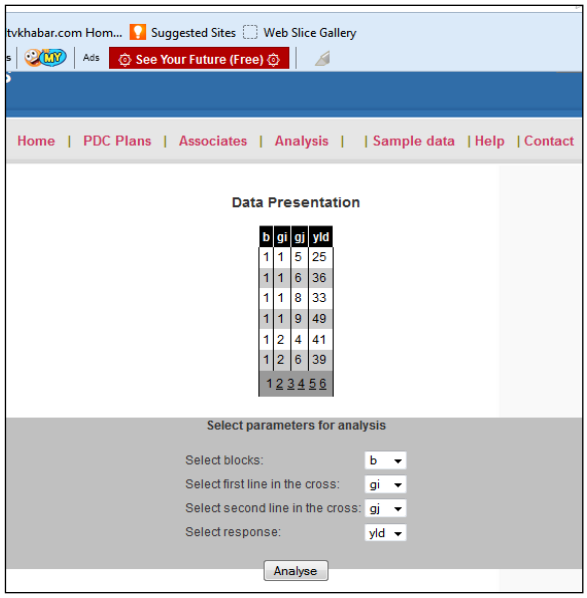
Home Page



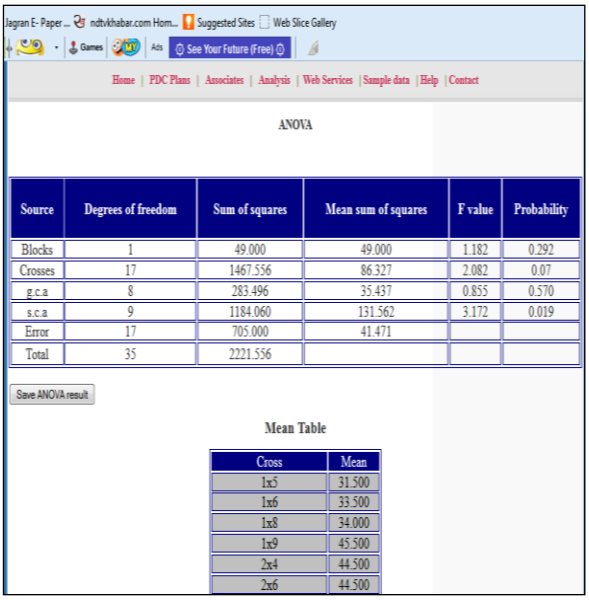
A PDC Plan Generated







Data Presentation for Analysis

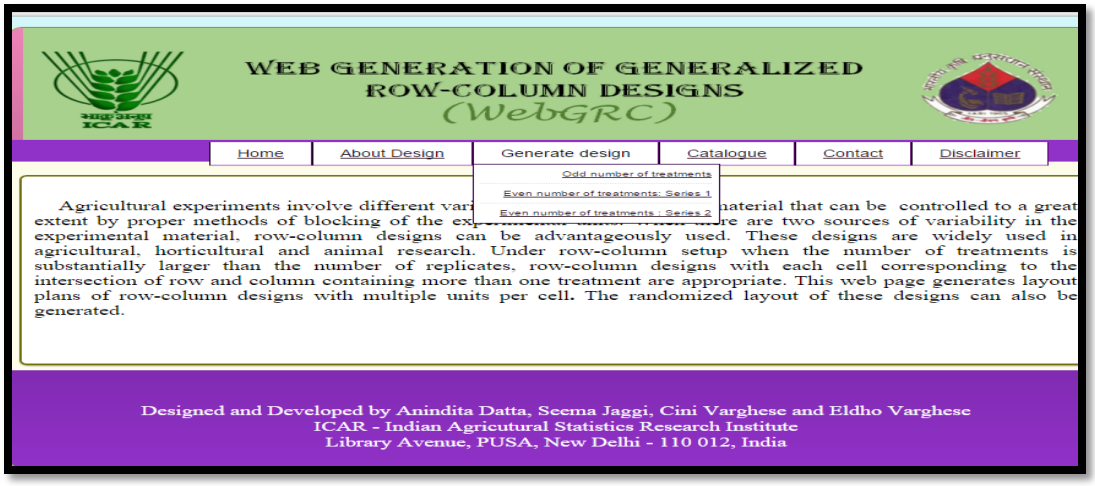


Output of Analysis

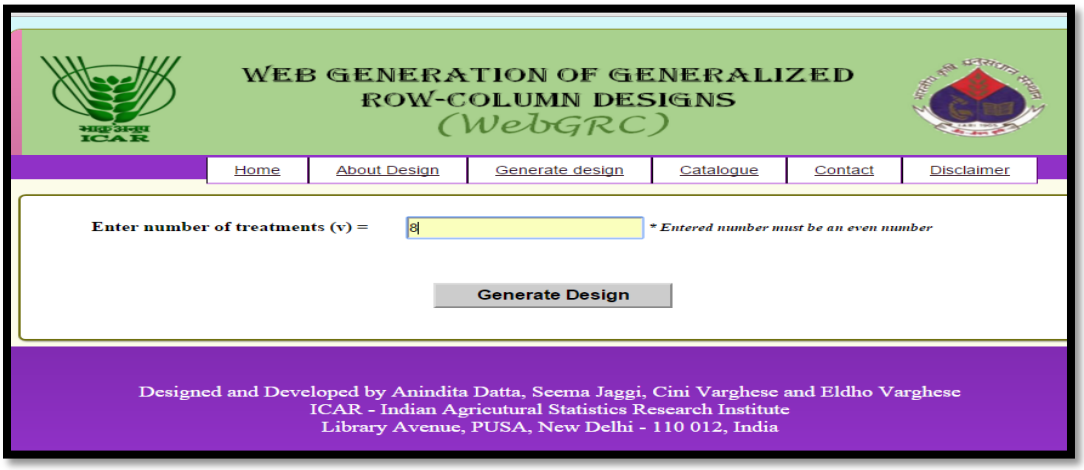
7. Web Solution for Generation of Generalized Row-Column Designs

Row-Column (RC) designs are useful for situations when there are evidences of cross classified variation in the experimental units. These designs are used to control variability in field and animal experiments. Most of the row-column designs developed in the literature have one unit corresponding to the intersection of each row and column. However, when the number of treatments is large with limited experimental resources, one may think of Generalized Row-Column (GRC) designs. GRC designs are used when there is more than one unit in each row-column intersection.

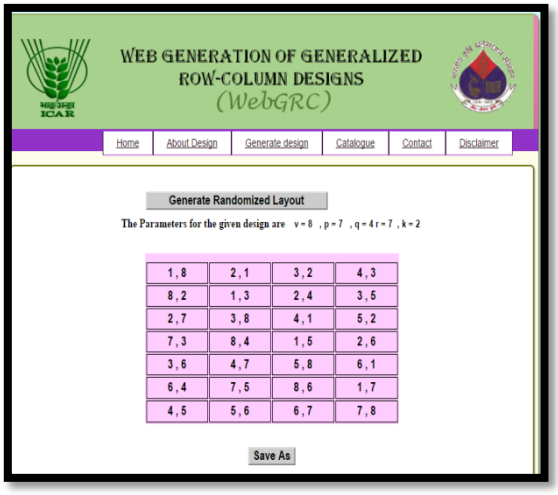
A number of GRC designs are available in the literature. For easy accessibility and quick reference of these designs by the experimenters, a software **Web Generation of Generalized Row-Column Designs (WebGRC)** has been developed. **WebGRC** generates design and gives randomized layout for various classes of GRC designs. Output can be exported to MS-Excel spread sheet for further use. The software is under testing and validation and will be made available at ICAR-IASRI website.



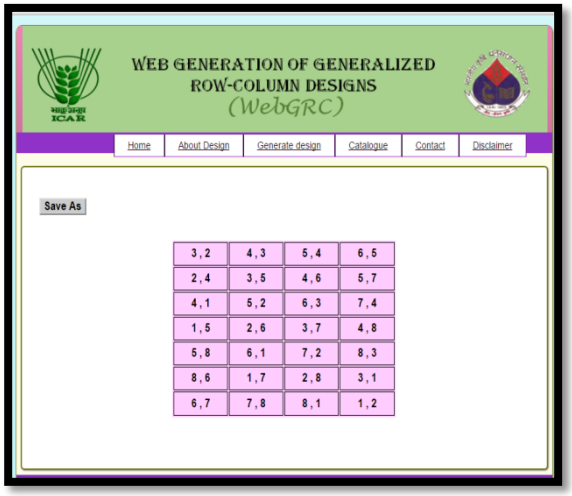
Home page GRC Designs



Generation of GRC Design



GRC Design for v = 8



Randomized layout of design for v = 8

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