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Web-Enabled Software for Generation and Analysis of Partial Diallel Crosses

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SUMMARY

Partial Diallel Cross (PDC) plans can be used advantageously in breeding experiments to investigate the genetic properties of inbred lines involved in the crosses. The association schemes of Partially Balanced Incomplete Block (PBIB) designs have been used in the literature for obtaining PDC plans. With the advancement in web technology, it is desirable to generate PDC plans on web so that it is easily accessible to the statisticians and breeders. This paper describes a software, named *webPDC* (available at http://nabg.iasri.res.in/webpdc), developed for generation of PDC plans based on association schemes of PBIB designs. The software also analyzes the data obtained on PDC plan laid out in a Randomized Complete Block (RCB) design.

Keywords : Association scheme, Mating design, Partial diallel cross, Partially balanced incomplete block design, Web generation.

1. INTRODUCTION

The breeding experiments involve two types of designs, namely mating design and environmental design. Mating design is a procedure of producing the progenies, while environmental design is subjecting these progenies to the environmental conditions in a systematic manner and collect data on traits of interest. Diallel and partial diallel cross plans are the commonly used mating designs and Randomized Complete Block (RCB) design is the commonly used environmental design.

Diallel cross plans are being used in breeding experiments to investigate the genetic properties of inbred lines involved in the crosses (Griffing 1956a, 1956b). With increase in the number of lines, the total number of crosses involved in a Complete Diallel Cross (CDC) plan is likely to be large resulting in difficulty to handle all of them effectively. It is then desirable to go for a subset or sample of all possible crosses, which is known as Partial Diallel Cross (PDC) plan (Kempthorne and Curnow 1961). One of the ways of obtaining these sample crosses is using the association schemes of Partially Balanced Incomplete Block (PBIB) designs (Fyfe and Gilbert 1963, Hinkelmann and Kempthorne 1963, Das and Sivaram 1968, Narain *et al.* 1974, Arya and Narain 1977, Agrawal 1985, Kaushik and Puri 1989, Kaushik 1999, Varghese *et al.* 2004). The details of these association schemes can be seen in Raghavarao and Padgett (2005).

Although some literature is available on sampling the diallel crosses using the association schemes of PBIB designs, breeders are still following CDC plans with less number of parental lines because of the difficulties in selecting the sample crosses out of a set of large number of crosses. A good review on genetic crosses experiments is given by Singh *et al.* (2012). With the advancement in web technology, it is desirable to generate PDC plans on web so that it is easily accessible to the statisticians and breeders.

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Most of the standard statistical softwares do not provide the option for generation of PDCs plans. However, some of these packages can be used for carrying out the analysis. A software for cataloguing, generation and analysis of PDC plans has been developed by Sharma *et al.* (2005), but it is windows based. Another windows based package, SPAR 2.0 (Ahuja *et al.* 2008) provides the analysis of PDC plans obtained using circulant scheme.

This paper describes a web based software named, *webPDC*, for generation and analysis of PDC plans. This software is highly useful to breeders in their agricultural research and is accessible any time from any arbitrary platforms through internet.

Here, a software (*webPDC*) developed for generation of PDC plans based on association schemes of PBIB designs has been described. The software also analyzes the data obtained on PDC plan laid out in a Randomized Complete Block (RCB) design. This software is available at *http://nabg.iasri.res.in/webpdc.*

2. SOFTWARE ARCHITECTURE

webPDC is based on three-tier client-server architecture. It has three layers namely, User Interface or Client Side Interface Layer (CSIL), Business Logic Layer or Server Side Application Layer (SSAL) and Data Access Layer or Database Layer (DBL). Fig. 1 shows the architecture of *webPDC*.

1. **Client Side Interface Layer (CSIL):** CSIL has been implemented using Hyper Text Markup Language (HTML) and JavaScript. The CSIL consist of forms for accepting information from the user and validating those forms using JavaScript. Web page designing was done using Cascading Styling Sheet (CSS).

2. **Server Side Application Layer (SSAL):** SSAL has been implemented using (ASP.NET). The ASP.NET provides the web developers with a framework to create dynamic content on the server, which is secure, fast and independent of server platform. C#.NET language is used to develop code behind pages for various web forms.

3. **Database Layer (DBL):** Database layer is implemented using MS-Access database for storing user's information (i.e. login name, login password).

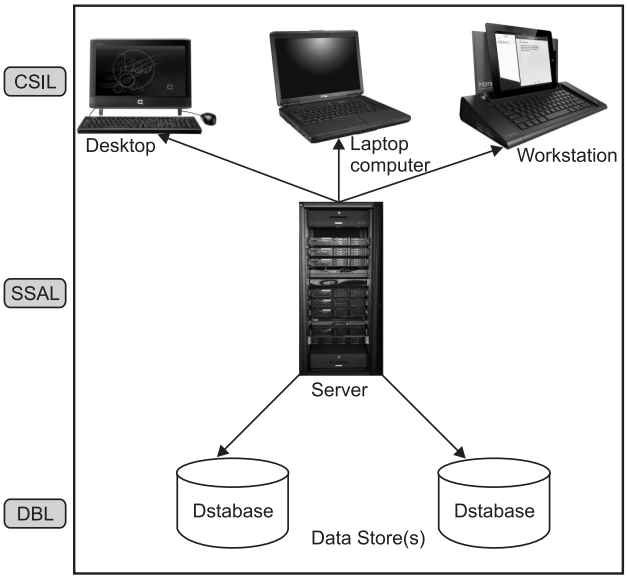

Fig. 1. *webPDC* 3-Tier architecture

webPDC is developed using Visual Studio-2005, an Integrative Development Environment for developing ASP.NET based web applications. Programming has been done using object oriented language named C#. Database connectivity has been done with ADO.NET which provides improved support for the disconnected programming model.

3. DESIGN OF SOFTWARE

webPDC has four modules namely generation of various associates of two associate class PBIB designs [PBIB(2)] and three associate class PBIB designs [PBIB(3)], generation of PDC plans based on association schemes, analysis of data and user management. The hierarchical structure chart for the design of the software has been shown in Fig. 2.

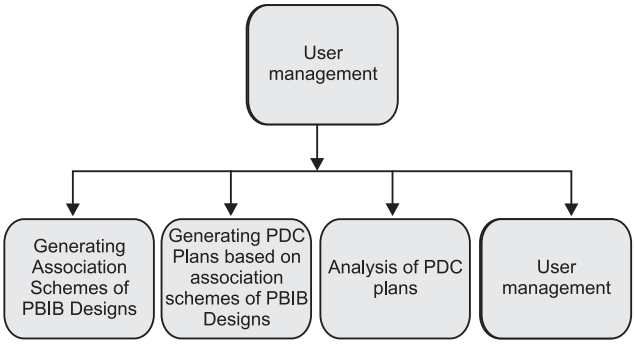

Fig. 2. Hierarchical chart showing the design of software

The main page of the software has links to web pages about general information on PDC, online user manual, download, sitemap and contacts as shown in Fig. 3.

Fig: 3. Home page of webPDC

webPDC generates the first and second associates of PBIB(2) and first, second and third associates of PBIB(3) association schemes and also PDC plans based on them. The details of association schemes included in PBIB(2) and PBIB(3) designs have been shown in Fig. 4. User management module provides the management for users accessing the application.

Proper software engineering practices and design are adopted for the development of the software. *webPDC* is completely menu driven and offers user-friendly screens organized and well arranged for users. The software is designed for multipurpose use, to meet the needs of students and teachers for demonstration of methods and concepts in generation of PDC plans using association schemes of PBIB(2) and PBIB(3) designs. Software is accessible online anywhere with the help of any browser from any arbitrary platform.

4. FEATURES OF SOFTWARE

4.1 Generation of PDC Plans

This module generates PDC plans using association schemes of PBIB(2) and PBIB(3) designs. Under association schemes of PBIB(2), it generates plans based on group divisible, triangular, circular and Latin square and under association schemes of PBIB(3), it generates plans based on extended triangular, rectangular, circular and nested group divisible association schemes. User can select an appropriate plan from the "PDC Plans" menu for getting the user interface for corresponding plan displayed as shown in Fig. 5.

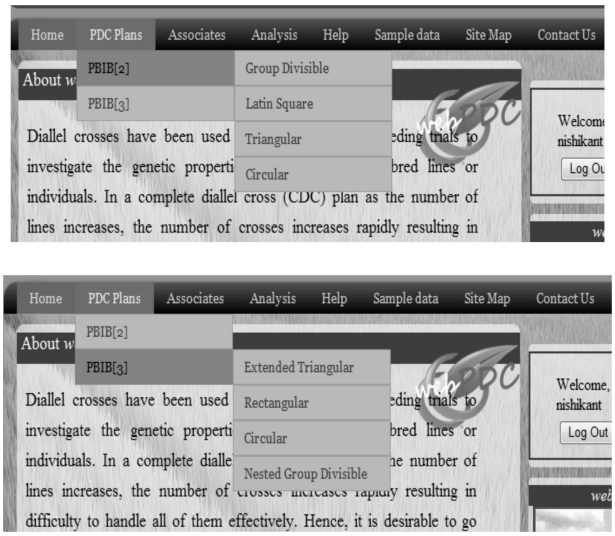

Fig. 5. Screenshot showing various PDC plans

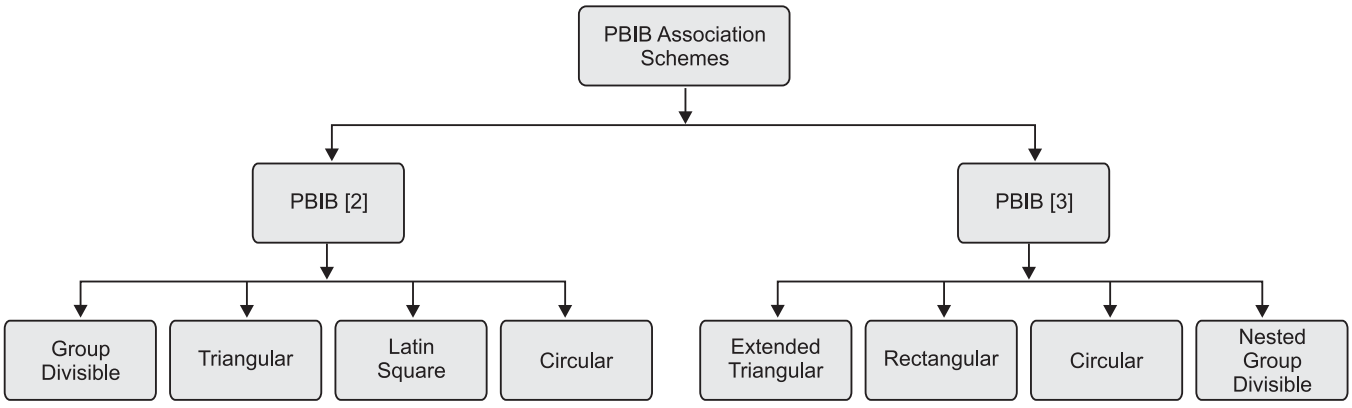

Fig. 4. Details of PBIB Association Schemes included in webPDC

Various input forms have been designed and developed for the generation of the above listed plans. User can enter the total number of lines and then click on "Generate Plan" to see the plan based on various associates. PDC plans for 12 lines obtained using PBIB(2) Group Divisible association scheme and using PBIB(3) Rectangular association scheme are shown in Fig. 6 and Fig. 7 respectively.

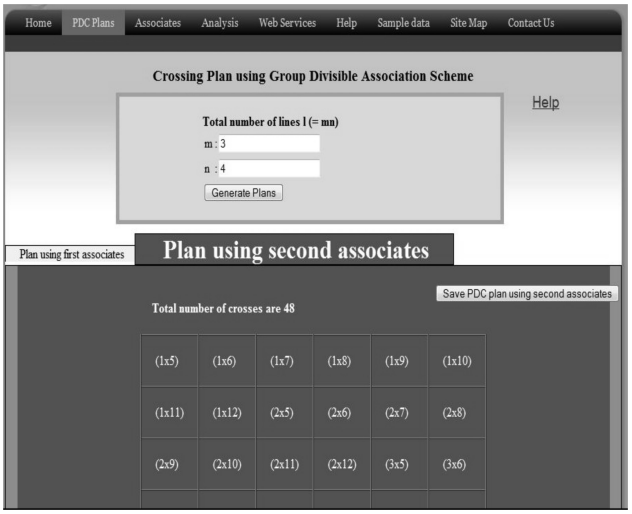

Fig 6. PDC plans obtained using PBIB(2) Group Divisible association scheme

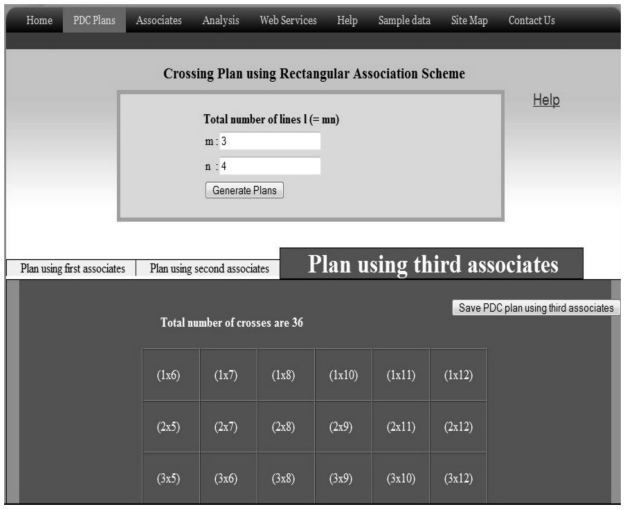

Fig. 7. PDC plans using PBIB(3) Rectangular association scheme

webPDC also provides the facility to save the output in an Excel file for future reference as shown in Fig. 8.

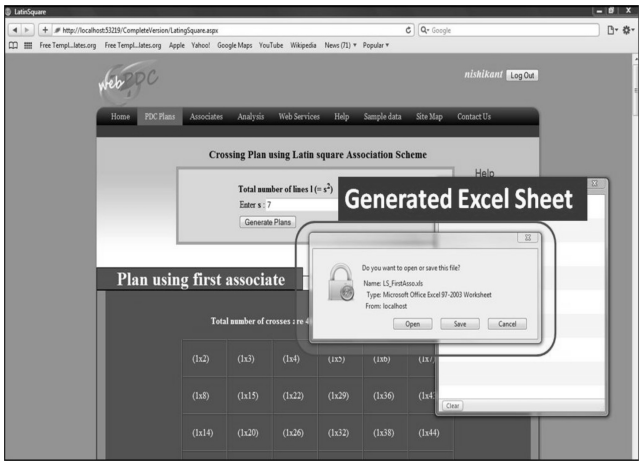

Fig. 8. Generation of Excel Sheet

4.2 Generation of Various Associates

Various modules have been developed for generation of group divisible, triangular, Latin square and circular PBIB(2) association schemes and for generation of rectangular, extended triangular, circular and nested group divisible PBIB(3) association schemes. User can select an appropriate scheme from the "Associates" menu for getting the user interface for corresponding scheme. Fig. 9 displays the first associates using triangular association scheme for 10 lines.

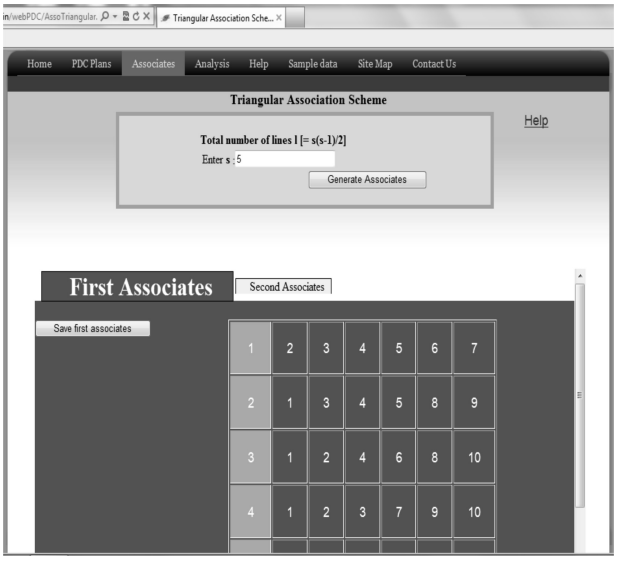

Fig. 9. Generation of first associates using triangular association scheme

5. ANALYSIS OF PDC PLANS

The software can analyze the data obtained on PDC plan laid out in a Randomized Complete Block (RCB) design (Singh and Chaudhary 2001). The analysis provides ANOVA, means for the partial diallel crosses, estimates of variance components and standard error of difference of gca estimates. Analysis module has main three components namely user interface management, input data management and statistical analysis engine. Any communication to software from users is handled through user interface at client side and input data handling is done by data management module. Statistical engine is implemented at server side and it contains various procedures required for analysis. User interface has been separated from the statistical engine to free software developers from interface problem. This engine contains the Dynamic Link Libraries (DLL) having various methods for analysis. The basic architecture of the analysis module of the software is shown below (Fig. 10):

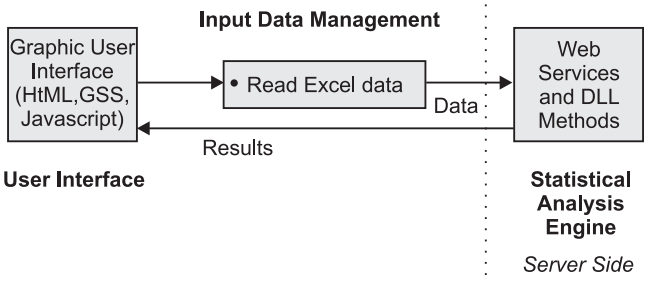

Fig. 10. Architecture of analysis system

A statistical engine has been developed in the form of an objected oriented C# library for analysis of PDC plans obtained using association schemes of PBIB designs. It implements the logic of standard procedures for the matrix operations, analysis of PDC plans and calculation of probabilities (P-values). It provides a framework which is very easy to use, extend, and integrate with other NET compatible software tools. This library could be easily customized and extended by adding new modules. Table 1 shows the list of methods included in this library.

Table 1. Libraries included

Name of Library	Methods
Matrix Operation	Matrix addition, Matrix subtraction, Scalar multiplication, Matrix multiplication, Matrix inverse
Analysis	Treatment Means, Grand Total, Block Means, C-matrix, Q-matrix, G-matrix
Probability	F probabilities

5.1 File Upload

User can upload the data from any worksheet in an excel file for analysis (Fig. 11). Software is compatible with excel sheet with version 2003 and 2007.

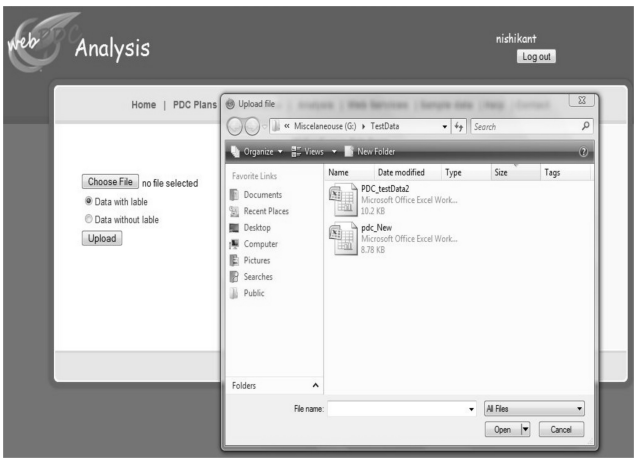

Fig. 11. Uploading excel file for analysis

For illustration, we have considered here the experimental data consisting of 18 crosses from 9 lines obtained using third associates of a rectangular association scheme laid out in a RCB design in 2 replications/ blocks (Table 2).

Table 2. Input data for analysis

Crosses	Block 1	Block 2
1 × 5	25	38
1 × 6	36	31
1 × 8	33	35
1 × 9	49	42
2 × 4	41	48
2 × 6	39	50
2 × 7	40	51
2 × 9	48	47
3 × 4	41	37
3 × 5	51	43
3 × 7	37	33
3 × 8	40	53
4 × 8	55	42
4 × 9	46	56
5 × 7	50	55
5 × 9	41	60
6 × 7	49	49
6 × 8	52	45

To analyze the data user may click on "Analysis" menu option and then upload the data file. After uploading the file, confirmation will appear which will be proceeded by selecting particular excel sheet containing the data. On next page, data will be presented and then block, first and second parental line involved in the cross, response has to be selected appropriately. Results are obtained by clicking on the "Analyse" button.

Fig. 12 shows the ANOVA table, Fig. 13 shows different crosses and their means and Fig. 14 gives the estimates of variance components along with standard error.

Source	Degree of freedom	Sum of squares	Mean sum of squares	F value	Proba-bility
Blocks	1	49.000	49.000	1.182	0.292
Crosses	17	1467.556	86.327	2.082	0.07
g.c.a	8	283.496	35.437	0.855	0.570
s.c.a	9	1184.060	131.562	3.172	0.019
Error	17	705.000	41.471		
Total	35	2221.556			

Fig. 12. ANOVA table

Cross	Mean
1 × 5	31.500
1 × 6	33.500
1 × 8	34.000
1 × 9	45.500
2 × 4	44.500
2 × 6	44.500
2 × 7	45.500
2 × 9	47.500
3 × 4	39.000
3 × 5	47.000
3 × 7	35.000
3 × 8	46.500
4 × 8	48.500
4 × 9	51.000
5 × 7	52.500
5 × 9	50.500
6 × 7	49.000
6 × 8	48.500
SE(Means)	4.554
SE(Difference of Means)	6.440

Fig. 13(a). Crosses mean table

Line	Estimates
1	–2.976
2	–0.314
3	–1.126
4	0.099
5	0.811
6	0.424
7	0.399
8	0.961
9	1.724
SE $(\hat{g})$	8.624
SE $(\hat{g}_i - \hat{g}_j)$	12.196

Fig. 13(b). GCA estimates table

Variance Components	
σ_g^2	–13.732
σ_s^2	110.827
σ_A^2	–27.464
σ_D^2	110.827

Fig. 14. Estimates of variance components and standard error

5.2 Online HTML Help

Software provides online HTML help about generation of PDC plans, association schemes and analysis (Fig. 15, Fig. 16 and Fig. 17) so that user can navigate to the desired option with the help of hyperlinks.

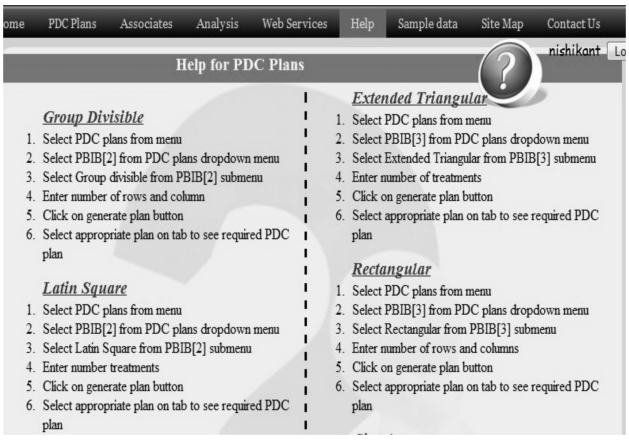

Fig. 15. PDC plans Help page

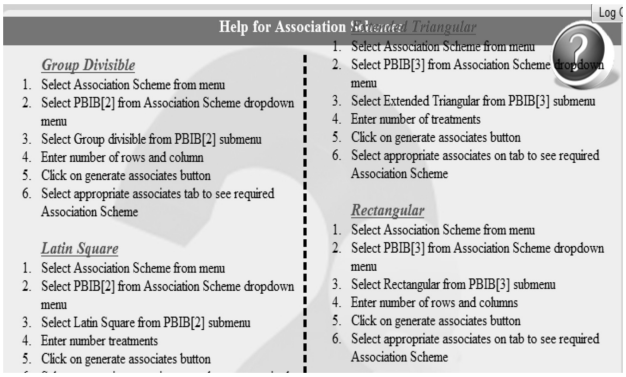

Fig. 16. Help for associates generation

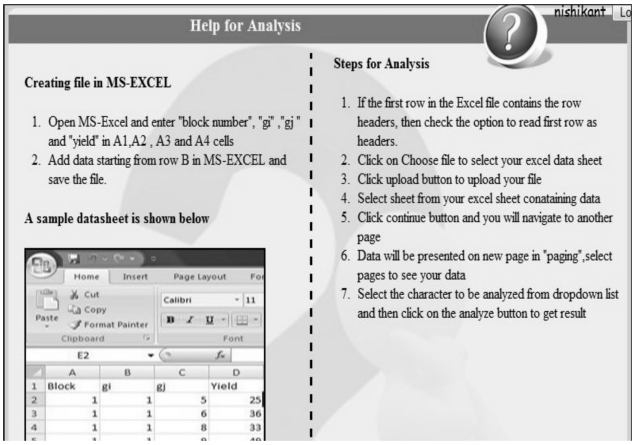

Fig.17. Help for creating excel sheet and using analysis module

6. CONCLUSION

webPDC generates the associates and PDC plans for eight various classes which can be accessed by users from any computer which is connected with internet. *webPDC* is completely menu driven and offers user-friendly screens organized and well arranged for users. The software is completely menu-driven and offers a user-friendly interface for its easy operability. It is designed for multipurpose use, to meet the needs of students and teachers for demonstration of methods and concepts in generation of PDC plans using association schemes of PBIB(2) and PBIB(3) designs. Software is accessible online anywhere with the help of any browser from any arbitrary platform.

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