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A Computer Software for PBIB(3) Designs and Partial Diallel Crosses

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SUMMARY

Designing an experiment is an important part of any scientific investigation. Block designs, complete or incomplete, are the most popular designs for agricultural field experiments. The purpose of this paper is to describe a PC-based software developed for cataloguing, generating and analyzing three-associate class partially balanced incomplete block (PBIB(3)) designs. The software also generates efficient cost effective plans for partial diallel crosses obtained through three-class association schemes and carries out its analysis in complete or incomplete block settings. Proper software engineering practices and design are adopted for the development of the software. The software runs under Windows 95 or later versions. The software is completely menu driven and offers user-friendly screens organized to simplify and reduce the number of entries. The software is designed for multipurpose use, to meet the needs of students and teachers for demonstration of methods and concepts in three-class association schemes and PBIB(3) designs. Further the software is useful for agronomists and breeders engaged in research in agricultural and allied sciences.

Key words : Association scheme, Partially balanced incomplete block design, Partial diallel cross, Efficient plan, Statistical package.

1. INTRODUCTION

Advancement in computing facilities has revised the way of thinking in designing of experiments. Though a large number of methods of constructing designs for various situations are available in literature, construction and selection of an appropriate design for a given situation is still a difficult task for the users, if pursued manually.

Incomplete block designs are used to reduce heterogeneity within a block when the number of treatments in an experiment is large. In the class of incomplete block designs, balanced incomplete block (BIB) design, given by Yates (1936), is the simplest one. However, BIB designs are not available for every parametric combination and even if a BIB design exists for a given number of treatments and block size, it may require too many replications, therefore in such situations, the partially balanced incomplete block (PBIB) design introduced by Bose and Nair (1939) may be used. These designs are defined on the basis of association schemes (Bose *et al.* (1954)). In these designs the variance of every estimated elementary contras among treatment effects is not the same. For some parameters, a PBIB design with two associate classes is either not available or if available, may require too many units and hence PBIB(3) design is an alternative. Several authors have contributed to the development of three-class association schemes and the designs based on them (see e.g. Bhagwandas *et al.* (1992), Das (1960), John (1966), Raghavarao and Chandrasekhararao (1964), Rao (1956), and Vartak (1955)).

Furthermore, PBIB designs and their association schemes are used by breeders for selection of sample crosses for given number of inbred lines or individuals. Diallel crosses are used in plant and animal breeding trials for investigating the genetic properties and potentials of inbred lines or individuals (Griffing (1956a), (1956b)). In a complete diallel cross plan, the number of crosses increases rapidly with the number of lines. Partial diallel crosses (PDC) are an effective solution for having a subset of all possible crosses. One of the ways of obtaining these sample crosses is through the association schemes of PBIB designs (Kaushik (1999), Narain (1993), and Singh and Hinkelmann (1995)).

Several softwares useful in designing and analysis of experiments are available either as stand-alone or as a part of statistical software package. Software like Statistica Design of Experiments (2002) deals with factorial designs and response surface designs for industrial research and AgroPlotter (2002) provides randomized layout of field experiments using a single-factor, two-factor and three-factor designs. However, it does not provide the statistical analysis of the data generated through these experiments. The packages like SPSS (Statistical Package for Social Sciences) and SAS (Statistical Analysis System) are expensive for users from developing countries and require separate modules or program codes to prepare the field layout. SPBD Release 1.0 (1997) developed at IASRI enables an experimenter to select, generate and give a randomized layout of a balanced incomplete block (BIB) design. The package can also perform the analysis of data obtained. In the literature, no software seems to be available for generation and analysis of PBIB(3) designs.

Association schemes of PBIB(3) designs can be used for obtaining efficient and cost effective PDC plans. Inspite of high cost, breeders still prefer to use complete diallel plans with less number of parental lines due to unavailability of suitable software for selecting the sample crosses out of a large number of lines as well as for the analysis of data obtained from them. Development of a computer software for selection, generation and analysis of PDC plans will help the breeders in this regard to a considerable extent.

The purpose of this paper is to describe a PC-based software developed for cataloguing, generating, randomizing and analyzing PBIB(3) designs. It generates various associates of treatments for different 3-class association schemes. The software also generates efficient plans for PDCs obtained through three-class association schemes, provides randomized layouts of these plans in complete/incomplete block settings and carries out analysis of data obtained through these experiments.

2. SOFTWARE DESCRIPTION

This is a stand-alone software developed using Microsoft Visual Basic 6.0 programming language ((1997), (1999)). The software is user-friendly, completely menu driven and requires minimum keyboard inputs. All controls are intuitive and user can discover how the software works. Software has seven modules as shown in Fig. 1.

2.1 Data Management

Data management module has been designed to create input data file in MS-Excel format. The format of the input data file is block number, treatment number and observation. An existing input excel data file can

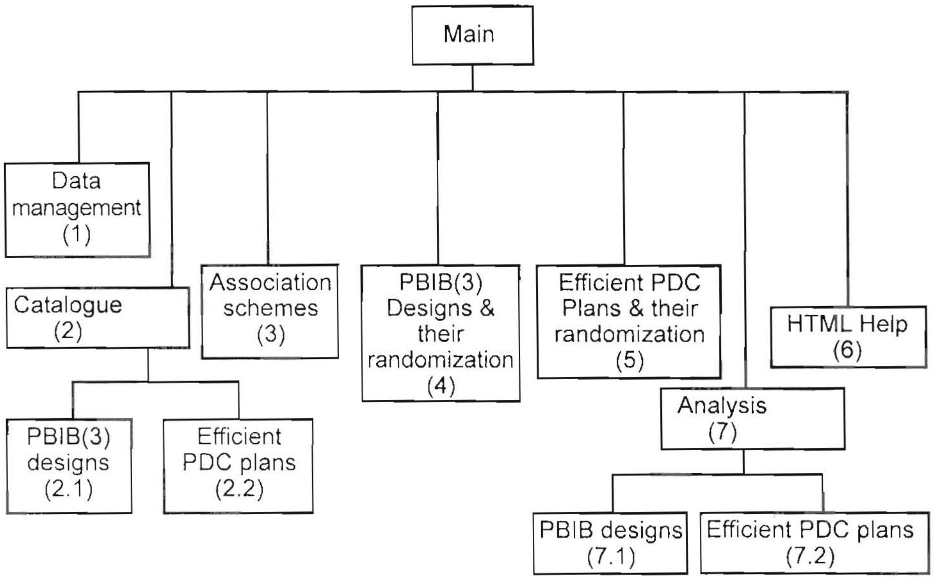


Fig. 1. Design of Software

also be opened for modifications using this software. Various outputs from software are available in text format with basic editing and formatting facilities.

2.2 Catalogue

This software contains catalogues of PBIB(3) designs and efficient PDC plans obtained from three-class association schemes. The software has a database containing these catalogues and is linked to user interface. This database is designed and developed in MS-Access 97. The catalogue of PBIB(3) designs consisting of parameters *v* (number of treatments), *b* (number of blocks), *r* (number of replications), *k* (block size), λ_1 (number of blocks in which two treatments, that are first associates, occur together), λ_2 (number of blocks in which two treatments that are second associates, occur together), λ_3 (number of blocks in which two treatments that are third associates occur together), n_1 (number of first associates), n_2 (number of second associates), n_3 (number of third associates), type of association scheme

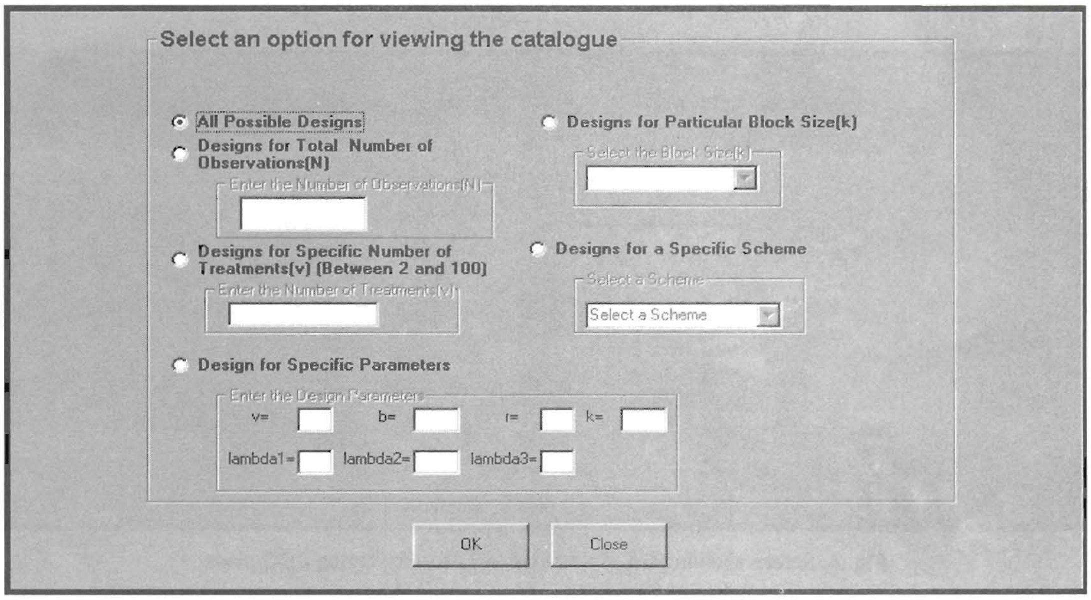


Fig. 2. Options for displaying PBIB(3) designs from catalogue

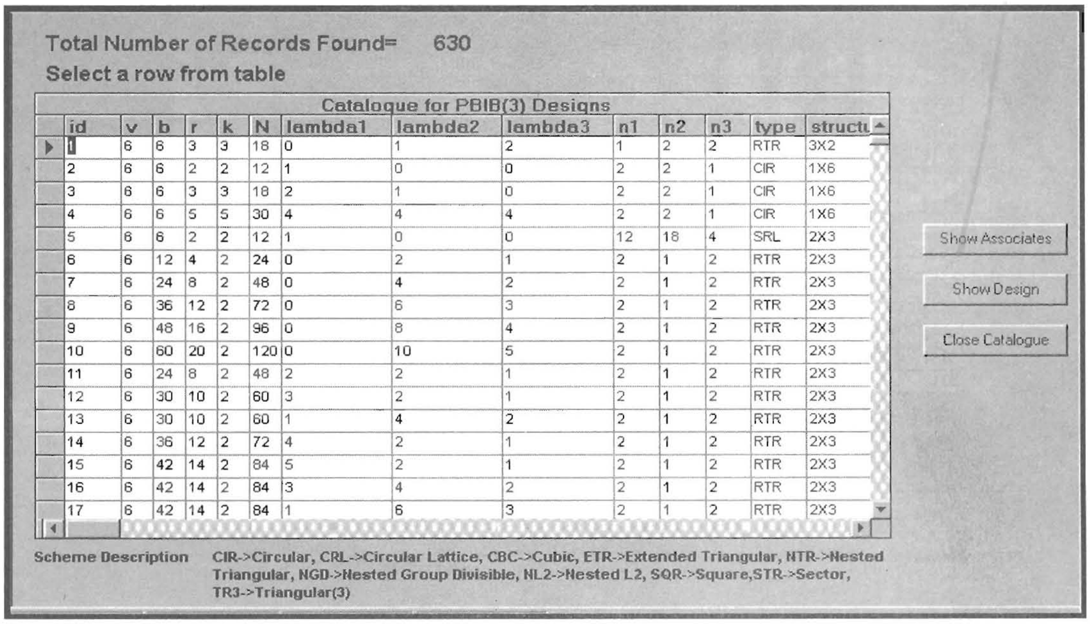


Fig. 3. Screen showing list of all PBIB(3) designs from catalogue

and treatment structure (like $v = mn$, $v = 2n^2$, etc.) has been prepared for v and $b \leq 100$, and r and The software can display designs for various options as shown in Fig. 2. The catalogue of PBIB(3) designs is linked with corresponding designs and association schemes (Fig. 3). User can select a row from catalogue and then click on button to display design/associates.

The software also contains a catalogue of efficient PDC plans consisting of number of lines (v) along with its structure, number of m^{th} associates (n_m, $m = 1, 2, 3$), number of crosses (s_m), information per cross for PDC plans (Inf_m), information per cross for complete diallel cross plan (Inf_{CDC}), efficiency (E_m), the association scheme used for obtaining PDC plans and treatment structure (for details, see Narain (1993)). The software can display catalogued PDC plans for each association scheme and for specific number of lines (v) as shown in Fig. 4 and Fig. 5. The catalogue of PDC plans is linked with generation of efficient PDC plan.

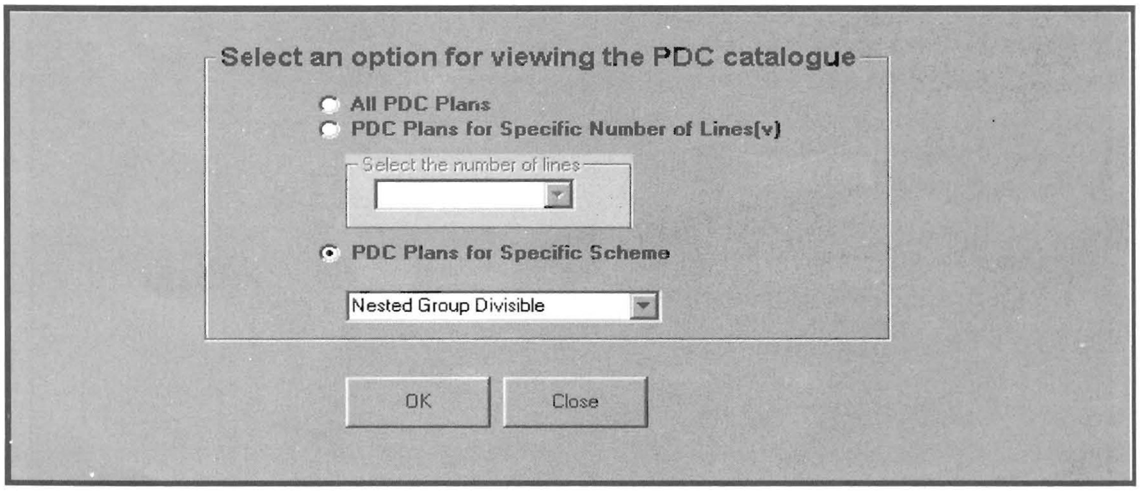
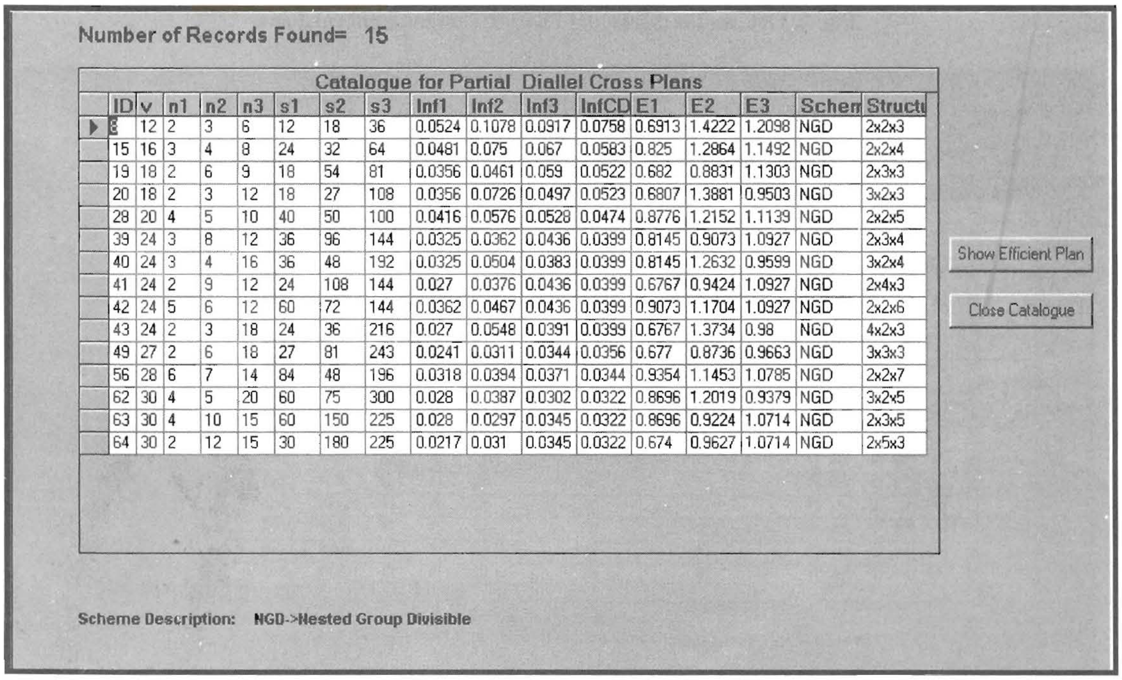


Fig. 4. Screen showing the available options for displaying PDC plans



Number of Records Found= 15

Catalogue for Partial Diallel Cross Plans

ID	v	n1	n2	n3	s1	s2	s3	Inf1	Inf2	Inf3	InfCD	E1	E2	E3	Schem	Structu
8	12	2	3	6	12	18	36	0.0524	0.1078	0.0917	0.0758	0.6913	1.4222	1.2098	NGD	2x2x3
15	16	3	4	8	24	32	64	0.0481	0.075	0.067	0.0583	0.825	1.2864	1.1492	NGD	2x2x4
19	18	2	6	9	18	54	81	0.0356	0.0461	0.059	0.0522	0.682	0.8831	1.1303	NGD	2x3x3
20	18	2	3	12	18	27	108	0.0356	0.0726	0.0497	0.0523	0.6807	1.3881	0.9503	NGD	3x2x3
28	20	4	5	10	40	50	100	0.0416	0.0576	0.0528	0.0474	0.8776	1.2152	1.1139	NGD	2x2x5
39	24	3	8	12	36	96	144	0.0325	0.0362	0.0436	0.0399	0.8145	0.9073	1.0927	NGD	2x3x4
40	24	3	4	16	36	48	192	0.0325	0.0504	0.0383	0.0399	0.8145	1.2632	0.9599	NGD	3x2x4
41	24	2	9	12	24	108	144	0.027	0.0376	0.0436	0.0399	0.6767	0.9424	1.0927	NGD	2x4x3
42	24	5	6	12	60	72	144	0.0362	0.0467	0.0436	0.0399	0.9073	1.1704	1.0927	NGD	2x2x6
43	24	2	3	18	24	36	216	0.027	0.0548	0.0391	0.0399	0.6767	1.3734	0.98	NGD	4x2x3
49	27	2	6	18	27	81	243	0.0241	0.0311	0.0344	0.0356	0.677	0.8736	0.9663	NGD	3x3x3
56	28	6	7	14	84	48	196	0.0318	0.0394	0.0371	0.0344	0.9354	1.1453	1.0785	NGD	2x2x7
62	30	4	5	20	60	75	300	0.028	0.0387	0.0302	0.0322	0.8696	1.2019	0.9379	NGD	3x2x5
63	30	4	10	15	60	150	225	0.028	0.0297	0.0345	0.0322	0.8696	0.9224	1.0714	NGD	2x3x5
64	30	2	12	15	30	180	225	0.0217	0.031	0.0345	0.0322	0.674	0.9627	1.0714	NGD	2x5x3

Show Efficient Plan

Close Catalogue

Scheme Description: NGD->Nested Group Divisible

Fig. 5. Screen showing the catalogue of PDC plans obtained from Nested Group Divisible Scheme

2.3 Generation of Associates for 3-class Association Schemes

The software generates the first, second and third associates of each treatment for the three-class association schemes namely circular, circular lattice, cubic, extended triangular, nested triangular, nested group divisible, nested L_2, nested triangular, rectangular, sector, square and triangular(3). User can select any scheme from drop down menu for association scheme to enter the treatment structure and then click on appropriate buttons to see the associates as shown in Fig. 6. Option is provided for editing and printing the results.

2.4 Generation of PBIB(3) Designs and their Randomization

An important feature of this software is to generate various PBIB(3) designs for schemes mentioned in Section 2.3. User can enter the treatment structure and then click to see the design. Randomized layout of the design can be obtained by selecting randomized layout button (Fig. 7). Option has been provided to get the printed output.

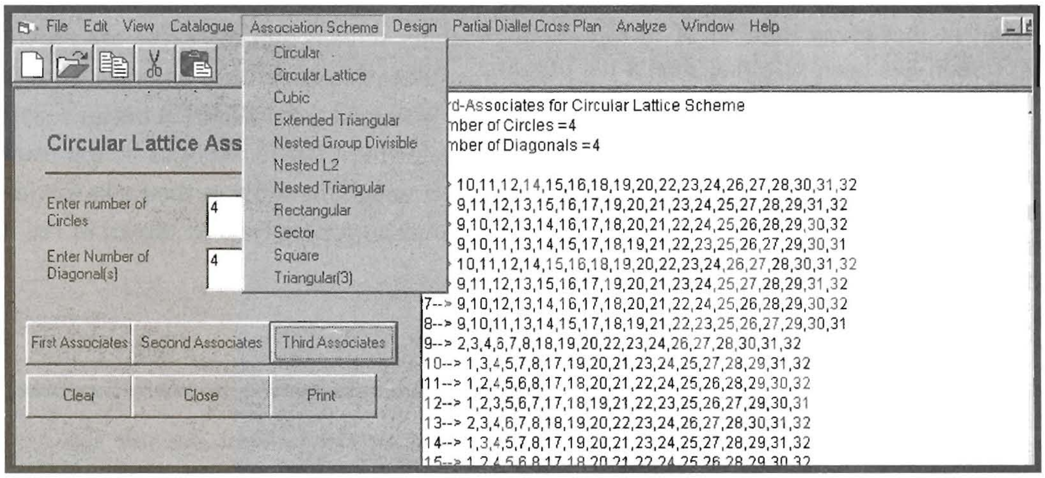


Fig. 6. Screen displaying third associates of 32 treatments for circular lattice association scheme

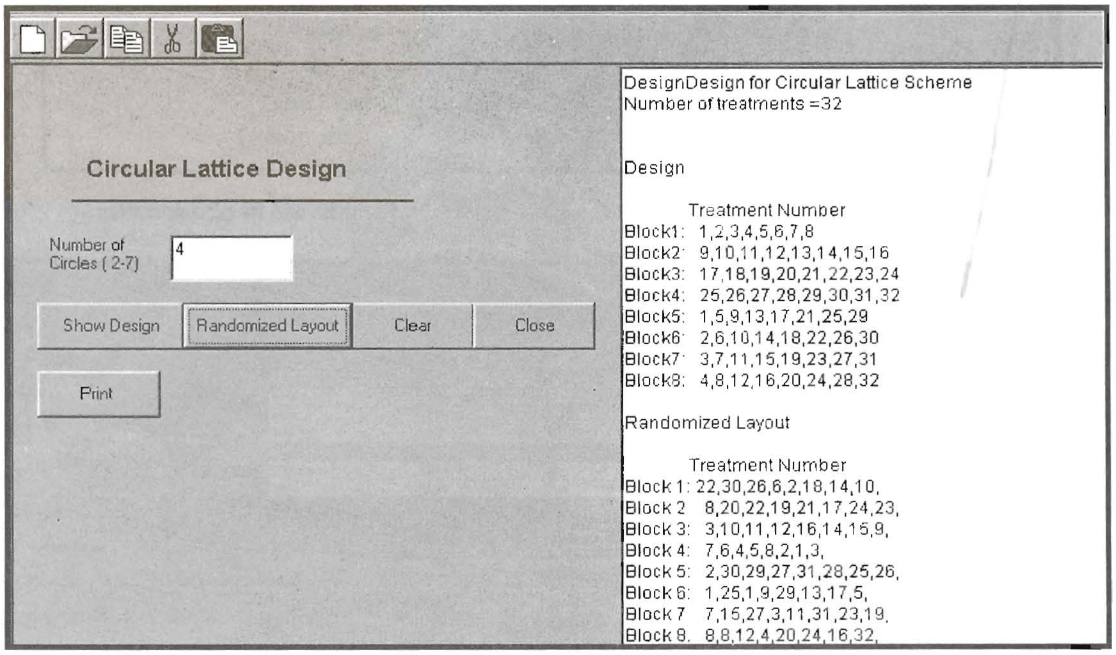


Fig. 7. Screen displaying the circular lattice design for number of treatments= 32

2.5 Generation of Efficient PDC Plans and their Randomization

This module of the software generates the efficient PDC plans obtained from three-class association schemes and provides their randomized layouts in Randomized Complete Block (RCB) design/PBIB(3) design. User can select any scheme, enter the required parameters and then click to see the corresponding efficient plan. Randomized layout for the most efficient plan can be obtained in RCB design (if the number of crosses are less than 30) and in PBIB(3) design (for number of crosses more than 30). If the user has selected RCB design option, then software will ask for the number of replications and generate randomized layout in that many number of blocks. If PBIB(3) design option has been selected, then a list of available PBIB(3) designs from the catalogue corresponding to the number of crosses in most efficient plan is displayed. User can select any of these designs, software automatically renumbers the treatments with crosses in the most efficient plan and then uses for further randomization.

Fig. 8 shows the generation of the most efficient PDC plans using circular association scheme when number of circles and diagonals are equal to 4. Number of crosses in most efficient plan is 16 for which list of available designs in PBIB(3) catalogue is displayed as shown in Fig. 9. Randomization can then be carried out using nested group divisible scheme (for example) with structure $2 \times 4 \times 2$ as shown in Fig. 9.

2.6 Analysis

The analysis of PBIB designs and PDC designs can be performed through this software. The software accepts the experimental data entered in MS-Excel form. User-friendly screens and messages are provided to analyze the data without writing any source code. Analysis of data obtained from PBIB(3) designs can be performed by selecting PBIB(3) designs option from analyze drop down menu. The software then asks for the required input parameters for analysis as shown in Fig. 10.

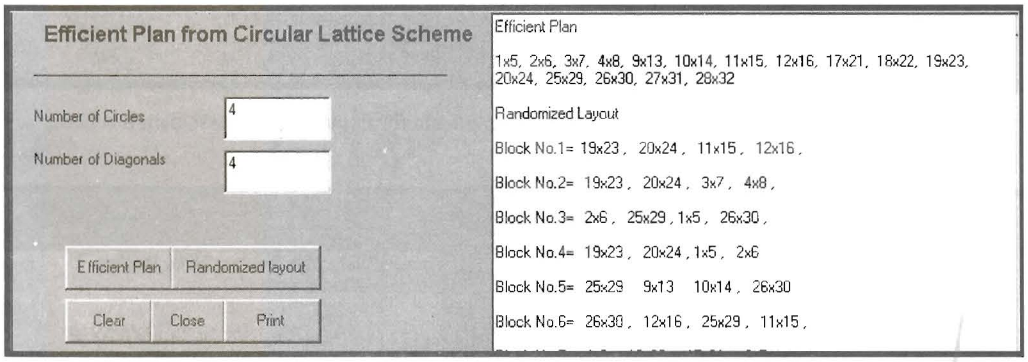


Fig. 8. Screen for generating efficient plan using circular lattice scheme and its randomization

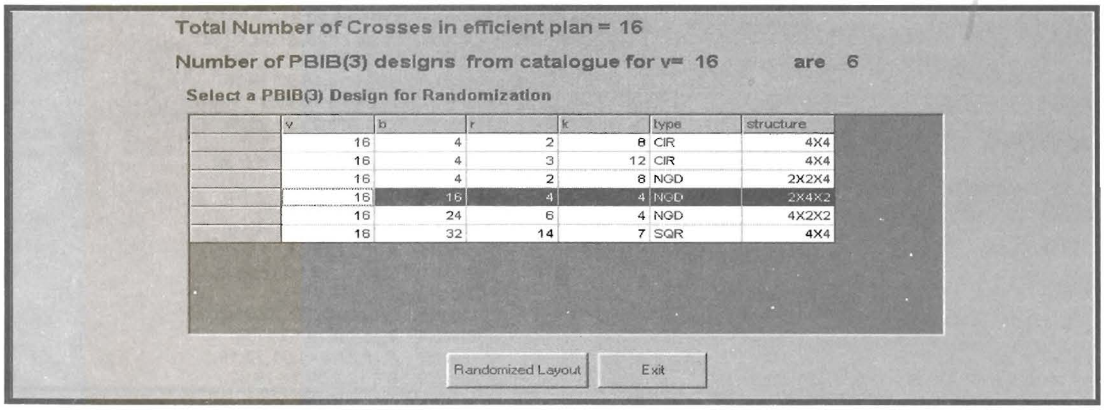


Fig. 9. Screen showing list of available PBIB(3) designs for $v = 16$

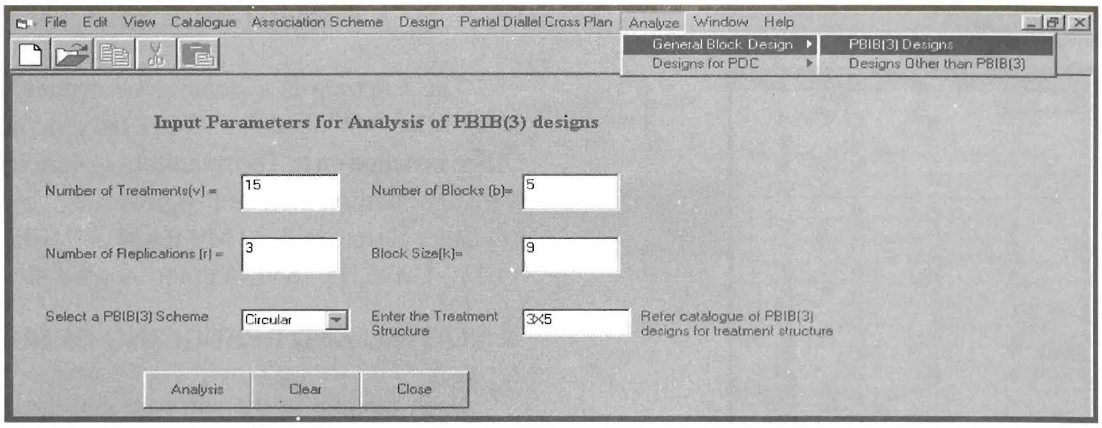


Fig. 10. Screen for entering the input parameters for analysis of PBIB(3) designs

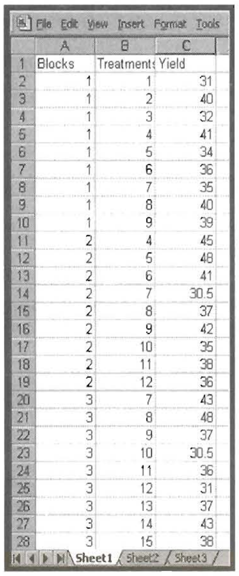


Fig. 11. Sample input data file in MS-Excel for PBIB(3) analysis

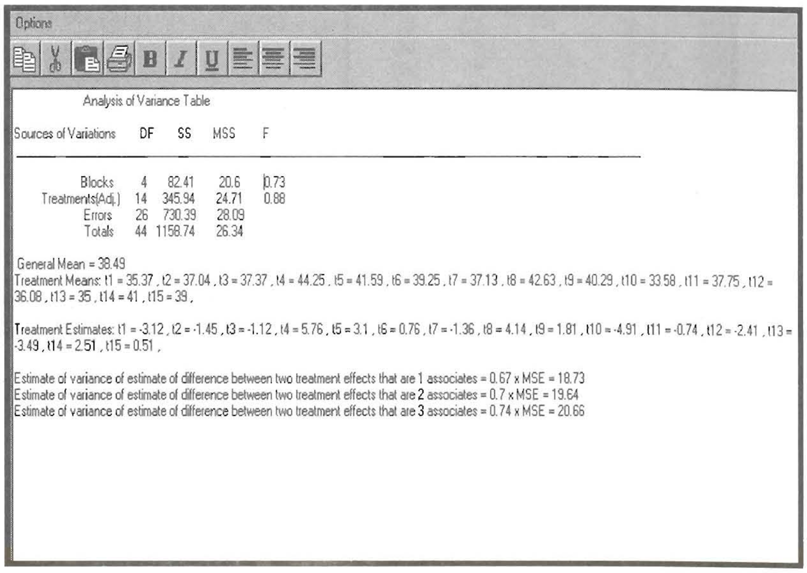


Fig. 12. ANOVA table

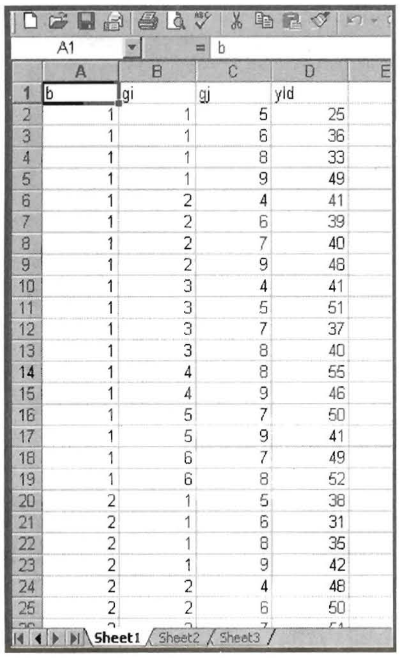
Synthetic data using circular design for 15 treatments in 3 replications is considered for illustrating the analysis using the software. Fig. 11 shows a part of this data and Fig.12 shows the final results after running the analysis procedure.

Data obtained from PDC plans can be analyzed by selecting PDC plan using association schemes option from analyze drop down menu. Required input parameters for analysis of PDC plans can then be entered using software followed by the name of input data file in MS-Excel which should be in the format of block number (b), i^{th} parental line involved in the cross $i \times j$ (g_i), j^{th} parental line involved in the cross $i \times j$ (g_j) and yield (yld). Fig. 13 shows a sample of synthetic data obtained using third associates of rectangular association scheme that is used for illustrating the analysis of PDC plan using software. Results of the analysis are shown in Fig. 14.

The results shown in Fig. 12 as well as in Fig. 14 are validated and verified with the results obtained manually.

2.7 HTML Help

HTML (Hyper Text Markup Language) Contents, Index and Search Help with Tool Tip Help are provided to users for easy operation of the software. Context Sensitive help is also made available. This module provides the HTML contents help on details of software, catalogues, association schemes, PBIB(3) designs, PDC plans and their analysis as shown in Fig. 15. This can be



b	gi	gj	yld
1	1	5	25
1	1	6	36
1	1	8	33
1	1	9	49
1	2	4	41
1	2	6	39
1	2	7	40
1	2	9	48
1	3	4	41
1	3	5	51
1	3	7	37
1	3	8	40
1	4	8	55
1	4	9	46
1	5	7	50
1	5	9	41
1	6	7	49
1	6	8	52
2	1	5	38
2	1	6	31
2	1	8	35
2	1	9	42
2	2	4	48
2	2	6	50

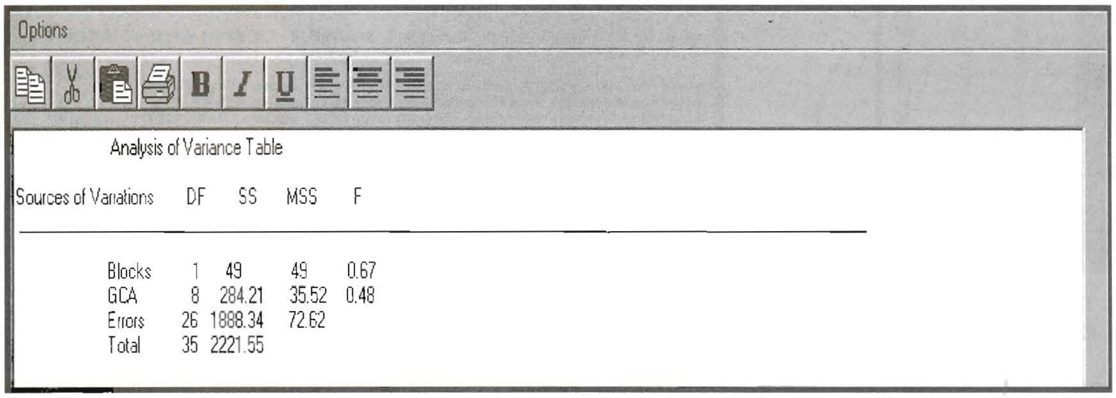
Fig. 13. Sample of input data file in MS-Excel for PDC analysis

3. SYSTEM REQUIREMENT

The software is a stand-alone capable of running under Microsoft Windows 95 or later versions with MS-Office installed on it. The minimum system requirements for its installation include P-II processor based personal computer system with 32 MB RAM, 4.0 GB Hard Drive, a CD – Drive, 15" SVGA color monitor etc.

4. TESTING AND DEBUGGING OF SOFTWARE

Each module of the software and the system as a whole has been tested and validated. Results obtained through the software have been compared with the results carried out manually and are found to be in agreement. To make the interface more user-friendly, user influence tests will be carried out once the β version of software is made available to the users.



Analysis of Variance Table

Sources of Variations	DF	SS	MSS	F
Blocks	1	49	49	0.67
GCA	8	284.21	35.52	0.48
Errors	26	1888.34	72.62	
Total	35	2221.55		

Fig. 14. ANOVA table

used as teaching material for demonstrating the methods for generation of various associates of 3-class association schemes, PBIB(3) designs based on these schemes and their analysis.

Some other features of the software are menus and toolbars with following facilities:

Edit: It provides editing facility like cut, copy and paste the text.

View: To show or hide status bar and tool bar.

Windows: For displaying windows in various styles like cascade, tile vertical, tile horizontal etc.

5. CONCLUSION

A computerized catalogue of PBIB(3) designs is provided in the software. The software generates the three different associates of each treatment for various three-class association schemes and generates designs and carries out randomization, if required. The software is also capable of carrying out analysis of the data obtained using these designs. The software is user friendly and does not demand thorough knowledge of computer language and design of experiments. The association schemes and methods of construction of PBIB designs based on these schemes are well explained with suitable

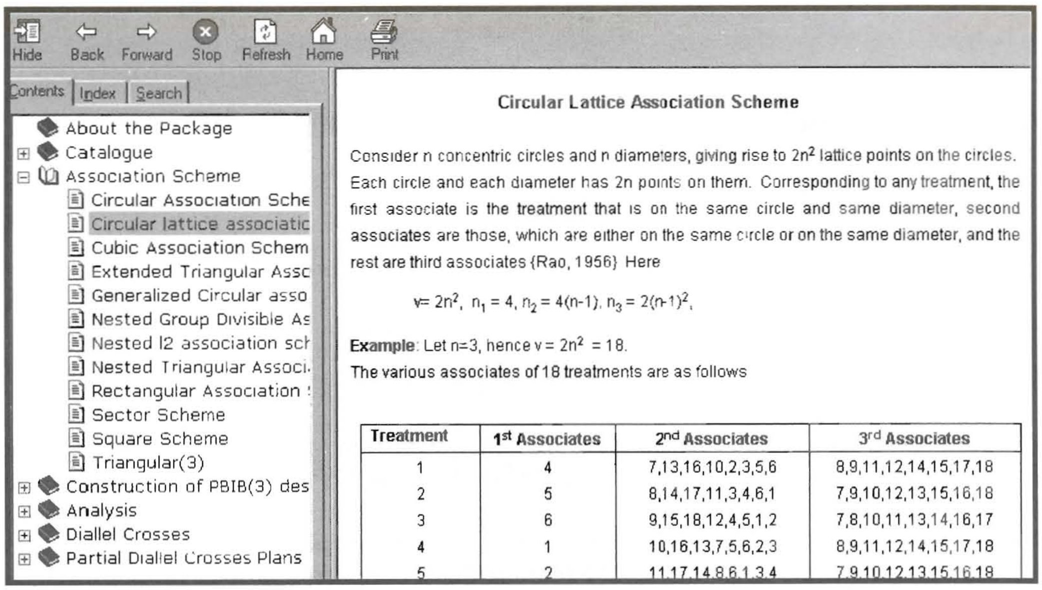


Fig. 15. Screen showing description of Circular Lattice Association Scheme using HTML Help

examples in the HELP which can be used as a reading material and teaching aid in the field of experimental designs. Further, the ready-made software will guide the plant breeders in sampling the diallel crosses. The software will also assist the breeders to analyze the data obtained from the PDC plans. Development of purpose oriented and user-friendly softwares like this for agricultural and allied sciences will encourage the researchers to conduct experiments using efficient and cost effective designs.

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