SPRMD – A Statistical Package for Cataloguing and Generation of Repeated Measurement Designs

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SUMMARY

Designs in which each experimental unit receives some or all of the treatments, one at a time, over a period of time are called repeated measurements designs (RMDs). These designs are extremely widespread in the literature. For ready referencing and potential use of these designs an up-to-date electronic catalogue is highly desirable. Further at present, no software seems to be available for the generation of these designs. In this study, a windows based statistical software is developed for cataloguing, generation and randomization of RMDs using Microsoft Visual Basic 6.0 programming language. This software is helpful to the statisticians and researchers in the areas like animal nutrition experiments, clinical trials in medical research, and long term fertilizer experiments in agriculture, educational studies, bio-equivalence trials etc.

Key words: Catalogue, Change over designs, Crossover trials, Generation of designs, Randomization, Repeated measurements designs, Residual effects, Statistical software, Switchover designs.

1. INTRODUCTION

Designing an experiment implies deciding how the experimental units are grouped, the treatments randomly allotted to these designs and the observations or measurements are taken to solve a particular problem in a valid, efficient and economic way. In experiments where the experimental units are human beings or animals, error variation cannot be controlled by grouping/ blocking as it also involves the physiological and genetic dissimilarities of the units. Hence, to eliminate such variation, it is desirable to design experiments in such a manner that each experimental unit receives some or all of the treatments, one at a time, over a certain period of time. Such designs are known as repeated measurements designs (RMDs) or changeover designs or crossover trials or switchover trials or designs involving sequences of treatments. They are commonly used in nutrition experiments with dairy cattle, clinical trials in medical research, educational/learning experiments, long-term agricultural field experiments, psychological experiments

and bio-equivalence trials. These designs are widely used when homogeneous experimental units are scarce. The distinguishing feature of such an experiment is that any treatment applied to a unit in a certain period influences the responses of the unit not only in the period of its application but also leaves residual effects in the succeeding periods. These designs are generally capable of providing treatments comparisons of high precision because they eliminate the difference among experimental units from the error variation.

A galaxy of scientists and research workers has contributed to the construction of various classes of these designs (Williams (1949), Bernblut (1964), Balaam (1968), Saha (1970), Lawless (1971), Dey and Balachandran (1976), Sharma (1977), Sharma (1981), Kershner and Federer (1981), Pigeon and Raghavarao (1987), Majumdar (1988), Varghese and Sharma (2000), Varghese *et al.* (2000) and Sharma *et al.* (2003). A good review of RMDs can be seen in Patterson and Lukas (1962), Jones and Kenward (1989), Afsarinejad (1990) and Hinkelmann and Kempthrone (2005). Literature on

RMDs are scattered and no software seems to be available for the selection of an appropriate RMD under a given experimental situation. Hence, a user-friendly software for RMDs will be highly helpful to the statisticians/experimenters involved in research.

This paper describes the Windows based software named SPRMD – Statistical Package for Cataloguing and Generation of RMDs. This package contains a catalogue of 216 RMDs falling under different classes of RMDs for number of treatments ≤ 20, number of periods ≤ 20 and number of experimental units ≤ 100. The package also generates 19 different classes of RMDs along with their randomized layouts.

2. SOFTWARE DESCRIPTION

SPRMD is developed using Microsoft Visual Basic 6.0 (VB6.0) as front end and Microsoft Access 2000 as back end. The software runs under windows 98/XP/2000/NT environment. The software contains the various DLLs (Dynamic Link Libraries) developed using VB6.0 for generation and randomization of RMDs. The GUI (Graphical User Interface) for the software is menu driven and requires minimal key board input. The software has four modules namely data management module, catalogue of RMDs, generation and randomization of RMDs and HTML Help. Fig. 1 shows

the hierarchical structure chart displaying the software design.

2.1 Data Management

This module has been designed and developed to display the experimental designs with their randomized layout. It supports following features to format the output generated as shown in Fig. 2:

♦ Saving the output in text, Excel and MS-Word file format.

♦ Printing the output with the facilities for displaying page setup and print setup.

♦ Editing facilities like Cut, Copy, Paste, Select, Clear Text, Undo and Redo.

♦ Searching and replacing any text in the Output Window.

♦ Formatting the output by changing background colour and text colour.

2.2 Catalogue

The software has a database containing a catalogue of RMDs. This database is designed and developed in MS-Access. Parameters [number of treatments (v), number of periods (p), number of experimental units (n),
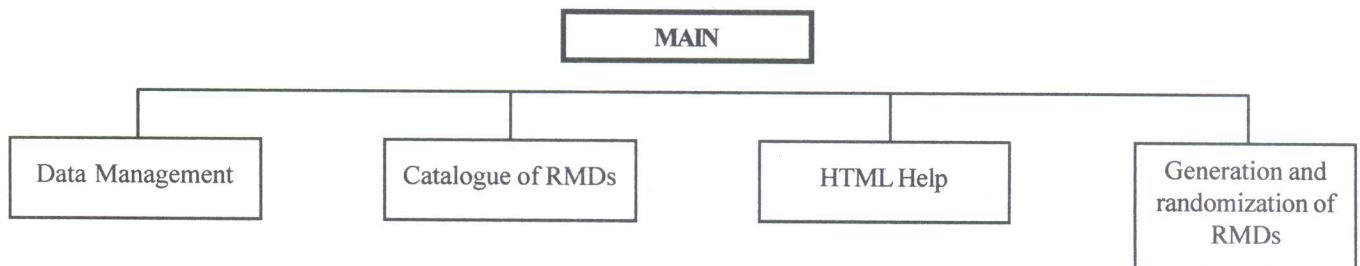

Fig. 1. Hierarchical structure chart showing the design of software
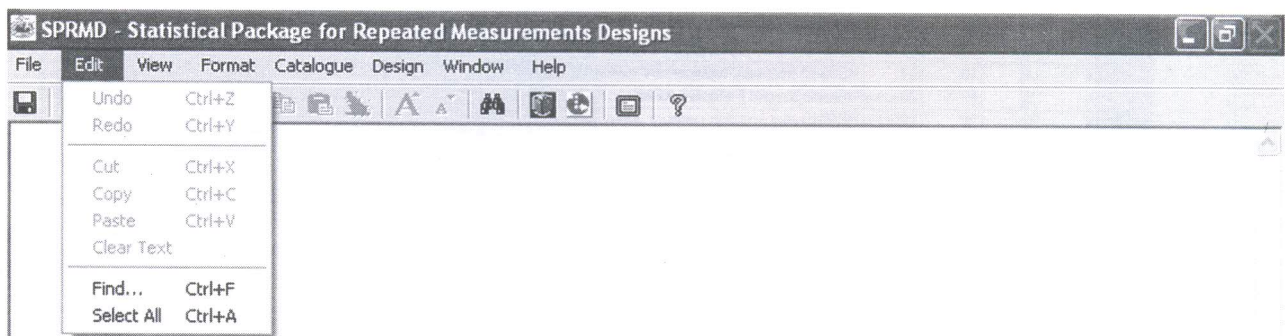

Fig. 2. GUI for data management module

total number of observations (N) and source/type of the design] of various classes of RMDs catalogued from literature have been entered into it. The catalogue of 216 RMDs has been prepared for $v \leq 20$, $p \leq 20$ and $n \leq 100$. The catalogue has completely GUI enabled interface with following features as shown in Fig. 3:

♦ Sorting in ascending and descending order by v, p, n and N.

♦ Filtering by parameter, by source type and for specific values of n, p and k. By parameter type user can filter the catalogue by v, p, n and N using operators like $=$, $\neq$, $\leq$, $\geq$, $<$, $>$ and for range of values (an illustration for $v = 4$ is given in Fig. 4).

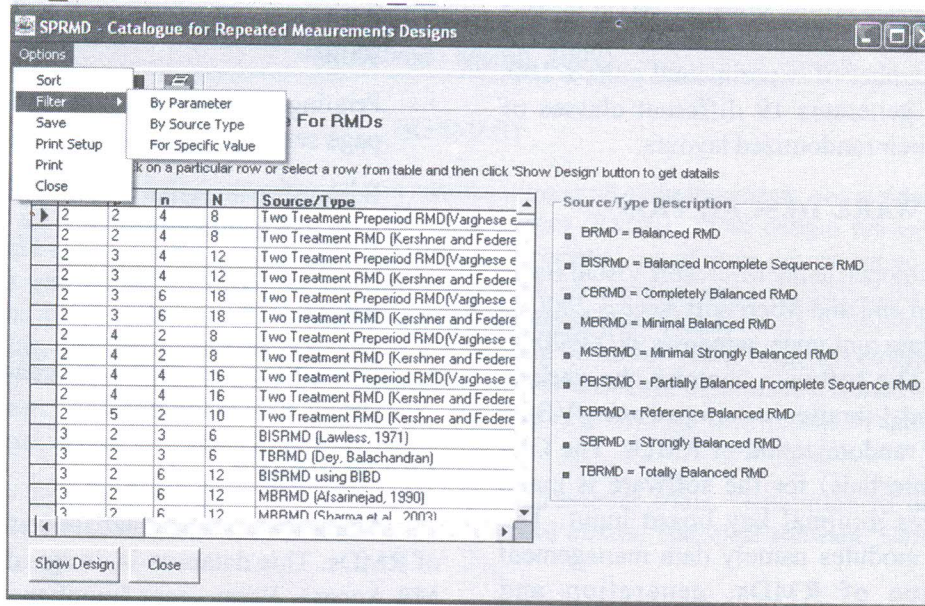♦ Saving the catalogue in text, MS-Word and MS-Excel file format.
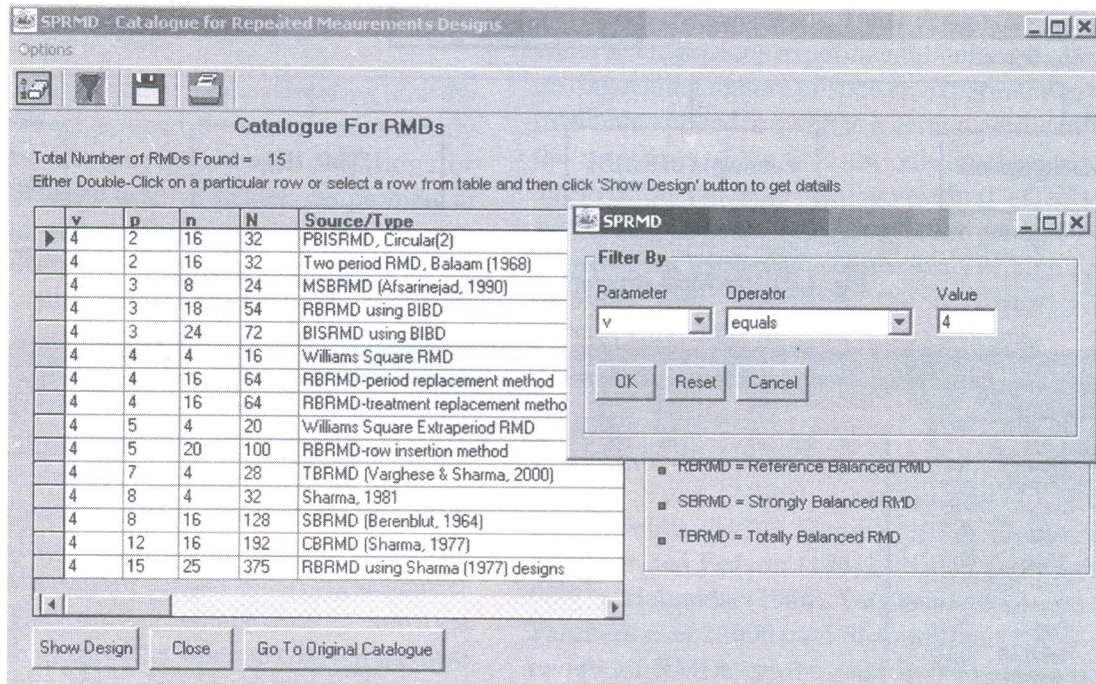

Fig. 3. GUI for catalogue showing the RMDs

Fig. 4. A Form showing catalogue filtering by parameters

◆ Displaying print setup window for setting print properties.

◆ Printing the catalogue.

The catalogue is linked to corresponding user interface. User can select a row from the catalogue and then click on "Show Design" button to display the user interface for the corresponding design.

2.3 Generation and Randomization of RMDs

Various modules have been developed for generation and randomization of following classes of RMDs:

1. Williams square RMDs given by Williams (1949)

2. Extra-period Williams square RMDs

3. RMDs given by Sharma (1981)

4. RMDs given by Berenblut (1964)

5. Two-treatment RMDs given by Kershner and Federer (1981)

6. Two-treatment pre-period RMDs given by Varghese et al. (2000)

7. RMDs obtained using Mutually Orthogonal Latin Squares for prime number of treatments

8. The class of circular totally balanced RMDs given by Varghese and Sharma (2000)

9. RMDs given by Sharma (1977)

10. Two classes of partially balanced RMDs given by Saha (1970)

11. Two-period RMDs given by Balaam (1968)

12. Totally balanced RMDs given by Dey and Balachandran (1976)

13. Balanced RMDs given by Lawless (1971)

14. Minimal balanced RMDs given by Sharma et al. (2003)

15. Balanced incomplete sequence RMDs based on Balanced Incomplete Block Designs by the method described by Patterson and Lucas (1962)

16. Partially balanced incomplete sequence RMDs obtained by developing Williams square designs using the block contents of Circular (2), Cyclic (2), Group divisible triangular (2) and Latin square (L_2) type partially balanced incomplete block designs as mentioned by Patterson and Lucas (1962)
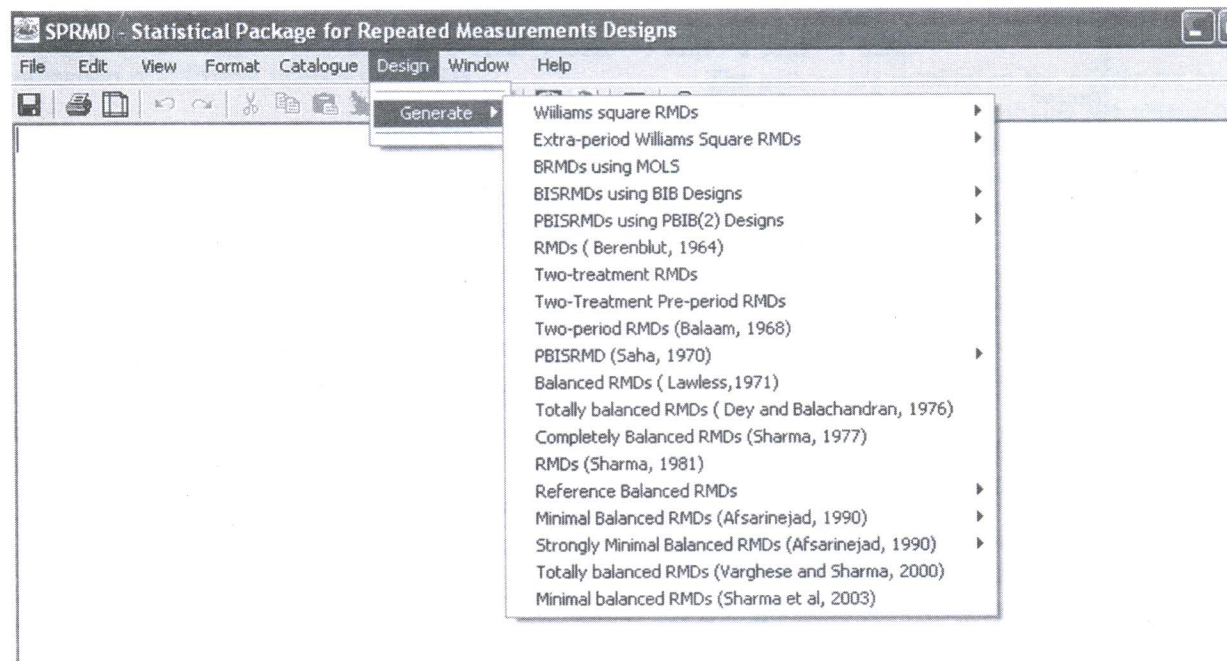
17. Minimal balanced RMDs given by Afsarinejad (1990)
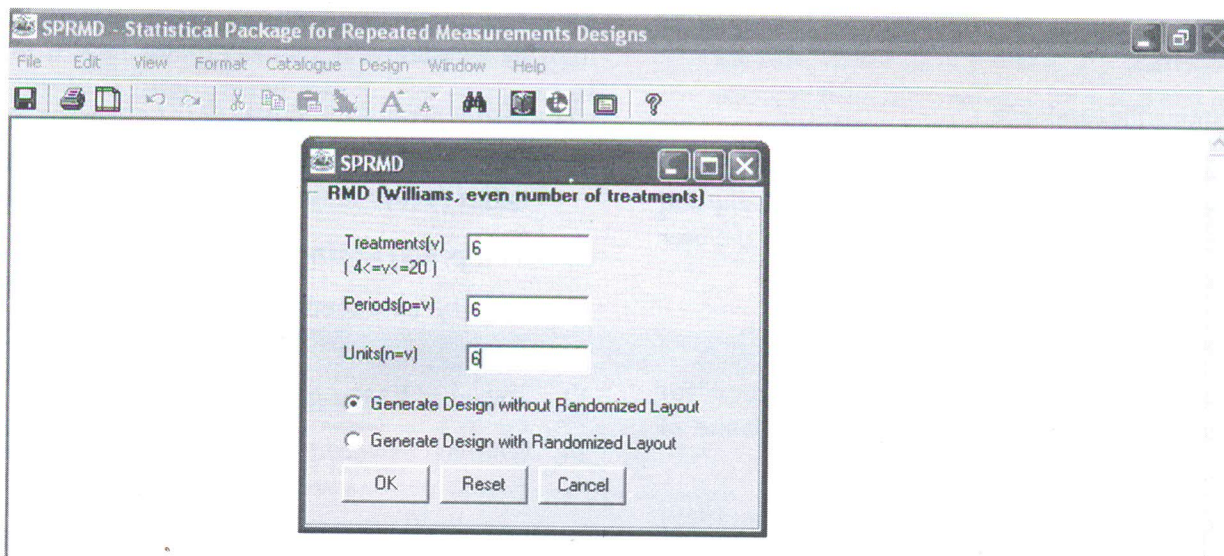

Fig. 5. Form showing list of generated RMDs

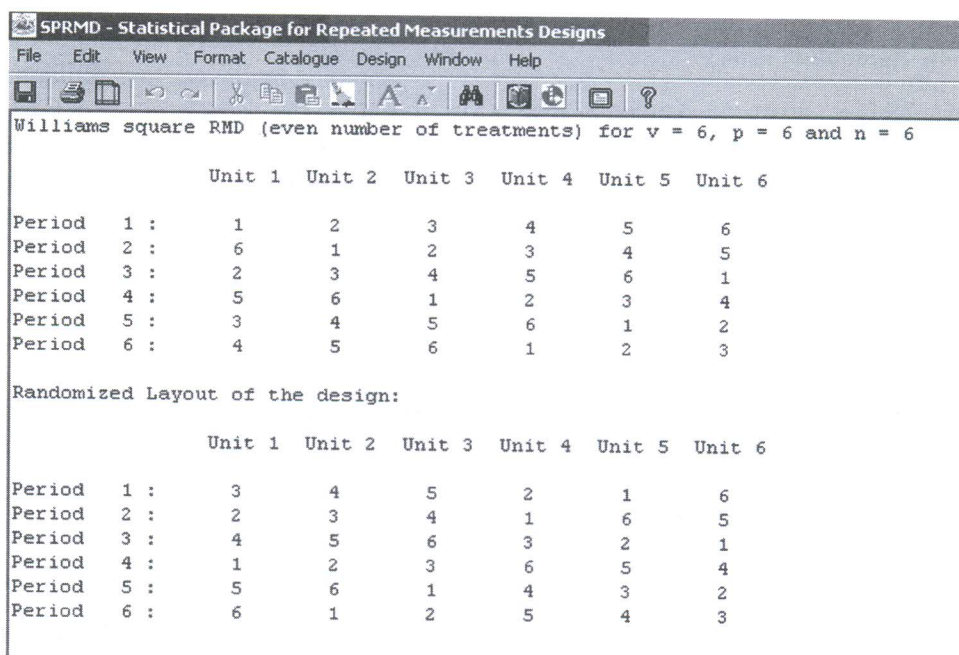**Fig. 6.** Form for entering the parameters for Williams square RMDs

Fig. 7. Generated Williams square RMD for v = 6, p = 6, n = 6 and its randomized layout

18. Strongly minimal balanced RMDs given by Afsarinejad (1990)

19. Reference Balanced RMDs given by Majumdar (1988) and Pigeon and Raghavarao (1987)

User can select an appropriate design from the "Design" menu for getting the user interface for corresponding design displayed as shown in Fig. 5.

Various input forms have been designed and developed for the generation and radnomization of the above listed designs. User can enter the treatment structure and then click "Generate Design" to see the design or click "Generate Design with Radnomized Layout" (Fig. 6) to view the design as well as randomized layout of that design.

In generated RMD, rows represent periods and columns, the experimental units. In RMDs, randomization is possible only for experimental units (columns) as treatments are allocated in sequence to experimental units over periods. Output for the above design along with its randomized layout plan is shown in Fig. 7.
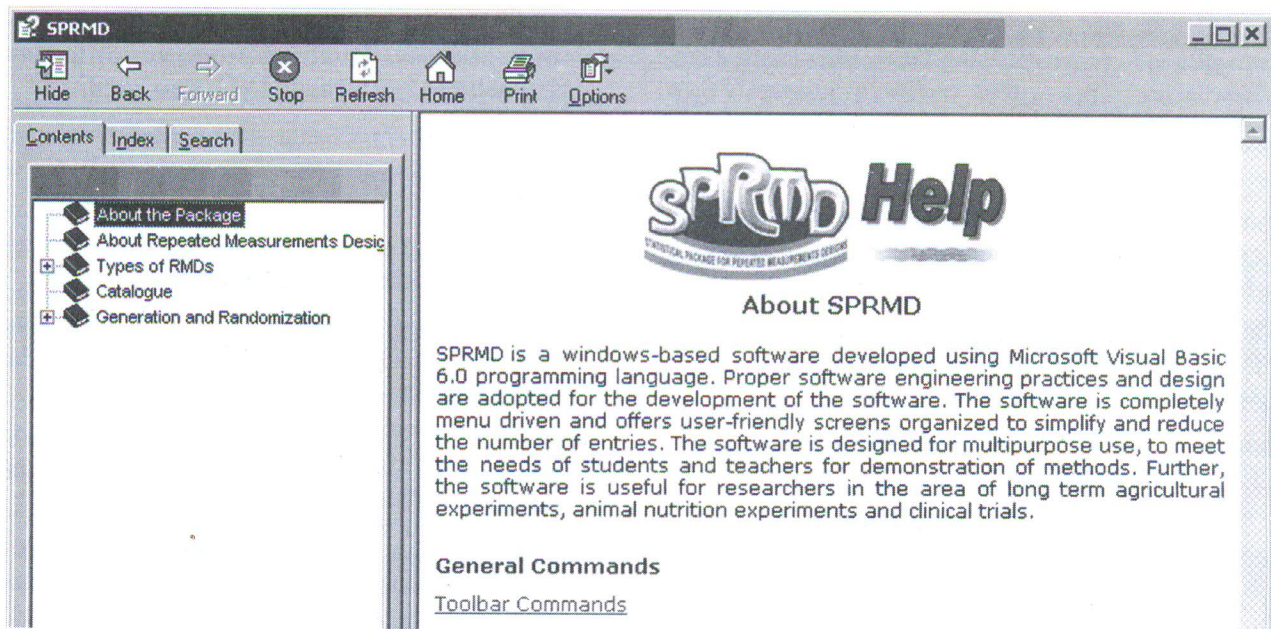
Fig. 8. Showing HTML Content, Index and Search Help

2.4 HTML Help

The software contains Hyper Text Markup Language (HTML) based content, index and search help as shown in Fig. 8. The help system has been developed using HTML workshop package. This can be used as reference for carrying out various software operations. It also contains the description of various classes of RMDs generated by the software. This can also be used as a teaching aid for demonstration of construction and randomization of different classes of RMDs.

3. SYSTEM REQUIREMENTS

This software was developed using VB6.0 and tested under the Windows 98/Windows XP/Windows 2000/Windows NT. 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-ROM drive or a USB port.

4. CONCLUSION

The SPRMD software provides a catalogue of 216 RMDs belonging to various classes. It generates the RMDs listed in the catalogue along with their randomized layouts. The software is completely menu-driven and offers a user-friendly interface for its easy operability. This software is intended to be useful to the statisticians and researchers in agriculture and allied areas. The software provides HTML help that can be used as a teaching or reference material on RMDs. Availability of the SPRMD software, a purpose oriented and user-friendly software for agricultural and allied sciences will encourage the researchers to conduct experiments using appropriate designs.

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