Web based Generation of Polycross Designs (webPD)

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SUMMARY

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. In this paper, the development of a web solution for generation of different classes of polycross designs based on client–server architecture has been discussed. The software webPD is easily accessible at any time from any arbitrary platform throughout the globe through the use of internet. This software provides freely available solution for the researchers, breeders and students working in this area.

Keywords: Polycross designs, Neighbour restricted designs, Octa neighbour balanced designs, Directional wind system, Web solution, Online catalogue.

1. INTRODUCTION

Various mating designs are used by breeders to develop improved genotypes. Selection of a good mating design is as equally important as selection of genotypes for a successful breeding programme. In case of breeding of cross-fertilizing, wind-pollinated, perennial species, polycross is the most widely adopted method of mass experimental crossbreeding. Polycross involves finding clones of strains that, upon crossbreeding with other clones or strains of the same species, yield the most productive plants which can be used in developing a new synthetic variety. Polycross nursery is a specific type of field design to ensure random mating among test genotypes. These polycross seed nurseries are useful in breeding programmes for crops like sweet potato, forage (eg: grass) and fodder (eg: alfalfa) crops, seed orchards for forest trees, *etc*. Thus, polycross trials are to be designed in such a way that each genotype has an equal chance of pollinating, or being pollinated by, any of the others. Polycross

designs were devised originally for agricultural plant improvement. Lot of work is available in literature which deals with different aspects of polycross designs [for example Wright (1962, 1965), Freeman (1967, 1969), Olesen and Olesen (1973), Olesen (1976), Morgan (1988), Freeman (1979), Janssens (1980), Aastveit and Aastveit (1990), Williams *et al.* (1999), *etc*.].

Across the globe, polycross nurseries may be under different conditions and therefore different types of polycross designs may be used accordingly. Further, design may be selected considering the nature of genotypes selected for breeding programme. Another factor to be considered is the total area required for the nursery as this contributes to the heterogeneity present. When some genotypes interfere in the growth or production of other genotypes, but have to be grown together, neighbour restricted design should be preferably used. Polycross designs for directional wind system is a better option when the topography

of the nursery is such that a known wind system may prevail in a certain direction. Further, when genotypes are planted in a small area without leaving much space between rows, designs balanced for neighbour effects from all possible eight directions are useful to have equal chance of pollinating and being pollinated by every other genotype. Varghese *et al.* (2015) obtained polycross designs to match all the above mentioned situations.

Construction of these designs involves a fair amount of mathematical understanding and hence, even though popular among breeders they are not widely being adapted by breeders. For easy accessibility and quick references of these designs by the experimenters, compilation and presentation of these designs at one platform is desirable. The rapid advancements on the internet technology have resulted in development of online software and hence expanding the horizon further. Many open source and commercial packages are available for analysis of experimental data but only limited number of software are available for generating readymade layouts of the required designs. An R-package named ''agricolae'' on experimental designs for plant breeding experiments has been developed (Mendiburu, 2013) to provide the methods for analysis and generation of various types of designs, but for limited parameters. A web based software AgroPlotter provides randomized layout of field experiments using some single-factor, two-factor and three-factor designs (AgroPlotter, 2002). JMP Design of Experiments is commercial software developed by SAS Institute for the generation and analysis of response surface, mixture, split plot, full factorial designs (Marcel, 2005). Design-Expert Software (Version 7.0) is a commercial software for generating designs for fitting response surfaces. More online software for generation and analysis of many other classes of field designs like partially balanced incomplete block designs, partial diallel crosses, cost effective response surface designs, designs balanced for indirect effects of treatments, *etc*. [please see Sharma *et al.* (2013), Taksande *et al.* (2012), Jaggi *et al.* (2015), Varghese *et al.* (2017) *etc*.] are available in public domain.

Considering the importance of polycross designs, a web-enabled software for the generation of polycross designs (webPD) has been developed, which generates five useful classes of designs [Varghese *et al.*, 2015]

helpful in various situations prevailing at polycross nurseries. An online catalogue (available at http://design.iasri.res.in/webpd/index1.html) of these designs is also developed. This paper describes the details of the software webPD.

2. ARCHITECTURE OF webPD

webPD is based on client server architecture and is accessible using any web browser. This software would help researchers in planning and designing their polycross trials with the help of web. User interface has been developed using Hyper Text Mark up Language (HTML), Cascading Style Sheets (CCS), and Javascript (Yehuda and Tomer, 1998). Java development kit (JDK 7) has been used as a platform for development of the software using NetBeans IDE 8.0.2. Input data management component has been developed using Java Server Pages (JSP). Various class libraries have been developed in Java programming language which contains the programs implementing methods for generation of polycross designs, basic matrix operations like addition, subtraction, multiplication, *etc*. It also contains the programs for output formatting. These are developed as reusable components that can be utilized in other Java based applications of various types like web application and web services. Fig. 1 shows the architecture of the software.

3. webPD: DESCRIPTION

This software is available in public domain at www.iasri.res.in/webPD. There are basically three major modules of the software namely generation of different classes of polycross designs as obtained by Varghese *et al.* (2015), catalogue of such designs and a brief description about the construction of different classes of polycross designs. Fig. 2 highlights the design of webPD. User can access the software by first clicking a button in the homepage entitled 'Go to webPD' (Fig. 3).

3.1 Generation of Designs through 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 (An illustration is given

in Fig. 4). Various web forms have been designed and developed for generation of these designs.

To generate Neighbour Restricted Block Designs:

(i) Click on '**Go to WebPD**' available in the home page of the software.

(ii) Keep the cursor on '**Generate Design**' link.

(iii) Select '**Neighbour Restricted Block Designs**' under '**Generate Design**'.

(iv) Enter a value of the parameter in '**Enter the value of m (≥3)'** [here, the entered number must be a prime number and the number of genotypes are v = 2m].

(v) After entering the value of the parameter, click '**Generate Design**' button and the generated design along with all parametric values will be displayed.

To generate Neighbour Restricted Row Column Polycross Designs, select '**Neighbour Restricted Row Column Designs**'. Then, enter the number of genotypes in '**Enter the value of v (≥4)**' [here, the entered number must be multiple of 4]. For generating Polycross Designs for Directional Wind System, select '**Polycross Designs for Directional Wind System**'. Then, enter the number of genotypes in '**Enter the value of v (≥7)**' [here, the entered number must be a prime number and (v-1) should be multiple of 3]. Further, to generate Octa Neighbour Balanced Polycross Designs - Series I, select '**Octa Neighbour Balanced Polycross Designs - Series I**' and enter the number of genotypes in '**Enter the value of v (≥5)**' [here, the entered number must be a odd number]. Finally, to generate Octa Neighbour Balanced Polycross Designs - Series II, select '**Octa Neighbour Balanced Polycross Designs -Series II**' and enter the number of genotypes in '**Enter the value of v (≥4)**' [here, the entered number must be a even number and (v+1) should be prime number]. After generating the designs, user can save the output for future use.

3.2 About Designs

The method of constructions along with example for all the above five different series of designs are described in the option '**About Design**'. Fig. 5 displays the about design section for **Polycross Designs for Directional Wind System**.

3.3 Online Catalogue

Online catalogue of all the five different series of designs for a specific set of parametric combinations has also been developed and integrated with webPD. User can also generate designs from the catalogue. Fig. 6 highlights the screenshot of the online catalogue for Neighbour Restricted Block Designs.

4. CONCLUSION

webPD is a web based software for generation of different classes of polycross designs. The software is menu driven and user-friendly. Online availability of the webPD in the public domain will help the researchers, more specifically the breeders, for getting a readymade solution with respect to polycross designs. Online 'catalogue' will serve as a readymade reference to the available design options for easy selection from user point of view. Researchers can learn more about these designs and their construction methods through 'about designs' menu.

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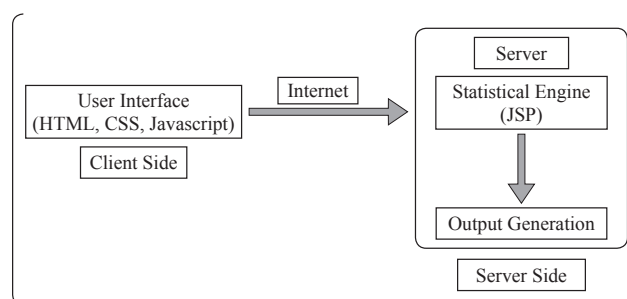
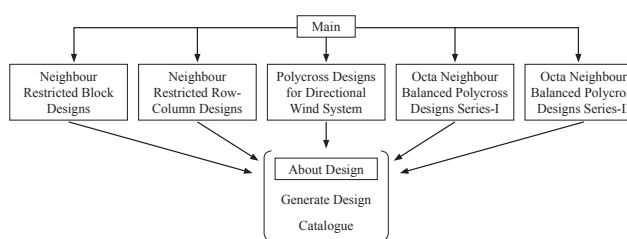## ANNEXURE

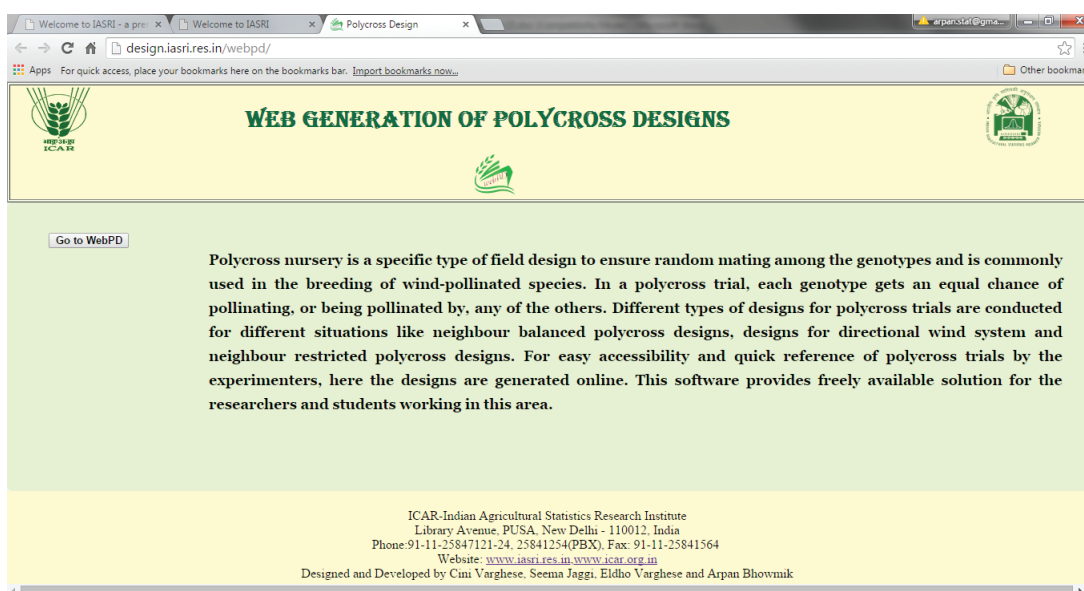**Fig. 1.** Architecture of webPD

Fig. 2. Design of webPD

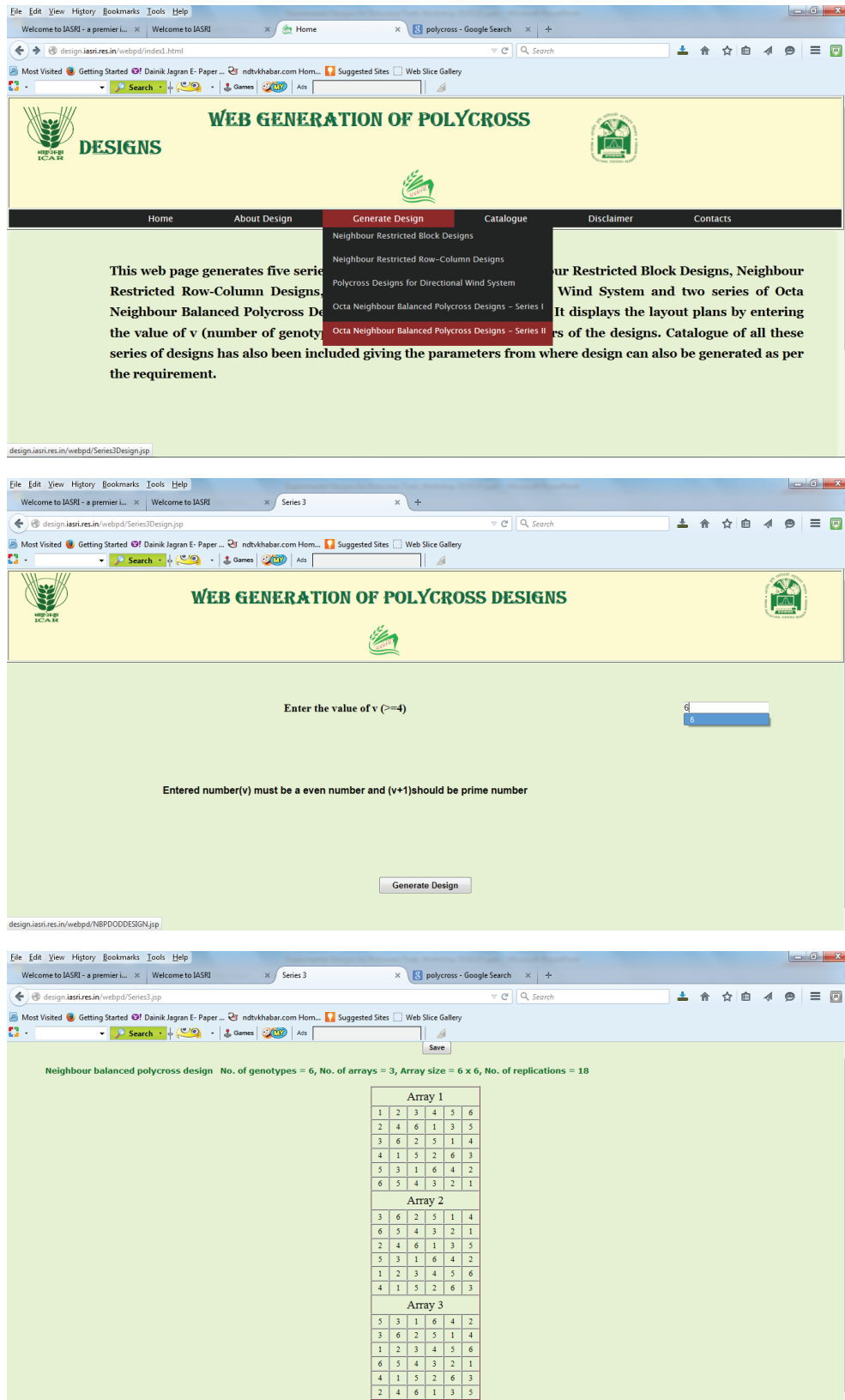**Fig. 3.** Home Page of webPD

Fig.4. Generation of Octa Neighbour Balanced Designs – Series II
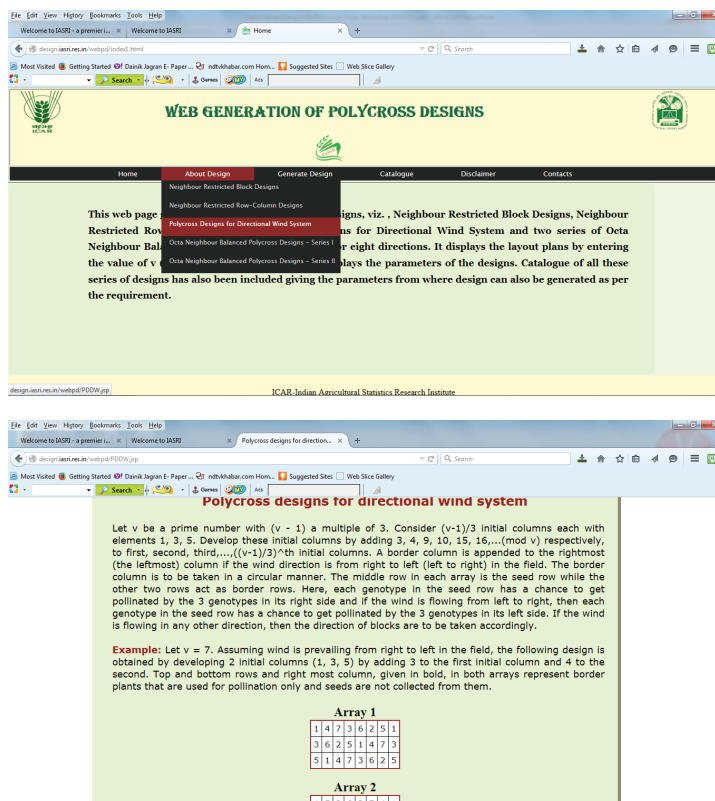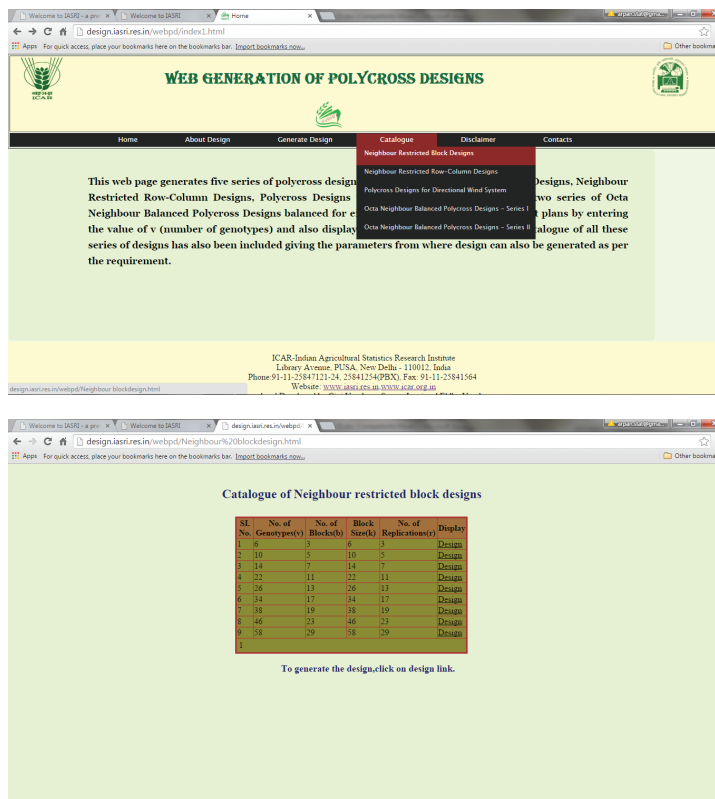
Fig. 5. 'About Designs' for Directional Wind System

Fig. 6. Catalogue of Neighbour Restricted Block Designs